JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LV.] MAY, 1868. [No. 5.

EDITORIAL.

ITEMS AND NOVELTIES.

The New Railway Bridge at India Point, Providence, R. I.—It was decided about forty years ago to replace the old bridge near this point, which had become, from the combined effects of age and wear, exceedingly dangerous.

In June of 1866, soundings were made to ascertain the nature of the river-bed, the depth of water, &c. A good solid bottom was found, consisting of gravel, covered with a layer of mud, on top of which is a crust of oyster-shells, forming the river-bed. The work then was discontinued until June of '67, when operations were again commenced. After carefully sounding the bottom in the places where the piles were to be sunk, no obstructions were discovered with the exception of the stump of an old pile, which was removed by the divers.

On account of the soft, muddy layer of several feet in thickness, which covers the solid bottom, it was deemed impossible to drive the piles from the ordinary pile driving scow. It was finally decided, therefore, to erect temporary platforms in places where the piles were to be driven. The construction of the platform was as follows: piles were driven in four rows, about twenty feet into the bed of the river, and about nine feet apart; these piles were capped with hard pine, about thirteen inches square, and then covered with spruce plank. This formed a substantial platform, upon which all the heavy work, such as driving the piles and cylinders, was performed.

The permanent piles are arranged in clusters of twelve for the two piers west of the draw, and also two groups under the draw contain the same number. The other groups, five in number, each contain nine piles.

The piles were driven in the following manner: the first pile driven in was sharpened on all sides, the bevel commencing about eighteen inches above the lower end, and the end left about four inches square; all the remaining piles that presented only one side to those already driven, were sharpened only on one side, and the corner piles and those that were in contact with other piles, were sharpened upon the two opposite sides.

The piles are encased in cast iron cylinders driven over them, the space between the piles and cylinders being firmly packed with concrete; the diameter of the cylinders west of the draw is six feet; the other five feet. The castings were made four and a half feet long, one and an eighth inches thick, having a flange four and five-eighths inches wide. The weight of the sections as they came from the moulds, was for those six feet in diameter, 5459 pounds, and those five feet in diameter, 4360 pounds.

The rough castings were covered with a coating of cement, which attached itself firmly to the rough scale, thus forming a solid, durable covering, the sections were then firmly bolted together and carried by a scow to the platform upon which they were hoisted, and from there forced down over the piles by means of a powerful screw-press. Notwithstanding the immense pressure brought to bear upon the cylinders, they were unable to penetrate the solid crust of oyster shells at the river-bed; the crust was then broken up by driving piles all around, and the cylinder again lowered; its weight alone, this time, carried it about four feet into the crust, and upon piling

about ten tons of iron together, with continued rocking (accomplished by means of levers), the cylinder was finally forced home; all the others were sunk in a similar manner.

The capping of the piers west of the draw consists of yellow pine, that of the draw is formed of oak; the pier upon which the east end of the draw rests, consists of granite, twenty-two feet long, and six feet thick, resting on piles driven to a depth of thirty feet below the river-bed. The draw, notwithstanding its immense weight, is easily turned by one man. The superstructure consists of the ordinary form of Howe Truss.

The first locomotive crossed the bridge February 28th, 1868, since which time the bridge has been regularly open for traffic. From various experiments that have been made, it is found to be exceedingly rigid. A heavy train passing over, causes a deflection in the centre of the spans less than a quarter of an inch.

The Proposed New Railway in Ontario, Canada, which has been for some time past the subject of much interest to the mercantile and farming community of the province of Ontario, and which is intended to connect the counties of Bruce, Wellington and Grey with the City of Toronto, has lately given rise to a very exciting debate in regard to the proposed gauge. The regular gauge of Canada is 5 feet 6 inches. The Company proposed making this gauge only 3 feet 6 inches. Much opposition was made to this deviation from the established gauge, but the 3 feet 6-inch gauge gained the point, upon the ground that a 5 feet 6-inch gauge would nearly double the expense per mile. This is an egregious error; the additional expense in first cost is merely nominal, and it is questionable whether the 5 feet 6-inch gauge is not, in the long run, in the wear upon the sleepers, &c., far cheaper than a smaller gauge. The more *practical* reason underlying this decision may be traced to the fact, that the Toronto dealers expect (by having a different gauge) to be enabled to re-ship and re-sell the products in Toronto, instead of their going directly to Montreal.

A Railway from China to India.—The columns of *Engineering* have for some time past been replete with discussions as to the practicability of laying a railway from India to China, *via* Burmah. The exploring party who were sent out to survey the route found it impracticable for a railway, except at an immense cost. This project has now, therefore, been abandoned, and the government has sent out a new expedition to open up the old trade route *via* Bhamo

and Irrawaddy. The expedition started on the 13th of January, fully equipped, and having a Chinese guide who speaks the Burmese language, and is to act as an interpreter. We shall be on the watch for further information of this interesting and important expedition, and will apprise our readers of their earliest reports.

The New Suspension Bridge at Niagara Falls, is very rapidly progressing; the work during the winter was greatly facilitated by a natural ice-bridge having formed directly beneath it, across which the cables and wires were carried with the greatest facility.

Some Experiments Relative to the Employment of the Electric Light. By F. P. Le Roux. Translated from *Les Mondes*.

In a preceding article, I have intimated that the voltaic arc, interrupted for a certain short space of time, can re-establish itself spontaneously. The passage of the current depends greatly upon the temperature of the interpolar spaces. As before stated, I have found it possible by means of this fact, to divide the electric light. By means of a distributive wheel, it is made alternately to pass through two electric light regulators, passing between these two at intervals, for example, of the $\frac{1}{20}$th of a second. Under these conditions, the two lights are, and remain perfectly steady.

It has been found advisable in these experiments, to have the carbon points smaller than usual, as the current then passes in a more continuous manner. If they are of square section, they need not be more than 0·157 inches. I am then convinced that if the carbon points can be procured sufficiently small, the electric light may be divided into two with advantage.

Unfortunately, we have been forced to employ carbon made from gas-coke, and the impurities of that material will not permit of its being made as small as it would be desirable to have the crayon. It is probable that if the carbon points could with facility be procured sufficiently small, the application of the electric light would receive a stimulus equal to that it experienced when De La Rive and Foucault substituted the carbon of the retorts for the vegetable carbon of Davy.

It is well to remark that machines, where electricity is produced by motion, from their very nature would be particularly adapted to that distribution we have explained.

I pass now to some experiments of another nature. I have found the electric light to suffer some modifications of the gaseous matters between the carbon points, on the score of color as well as

intensity. The employment of oxygen appears to me to offer some marked advantages. Under the influence of a very small jet of this gas, directed transversely through the carbon towards the middle of the interpolar spaces, the carbon is consumed more rapidly on the side which is exposed to the current of gas; these particles then arrange themselves excentrically; the arc is not so much exposed as ordinarily, when it flits about, sometimes on one side, and sometimes on the other, under the influence of the impurities contained in the carbon. In addition to this, the surfaces between which the arc jumps, which are those that furnish the larger part of the light, in place of being nominal to the axes of the carbon, are notably inclined to the side opposed to the direction of the jet of gas; by this means they present themselves more directly towards the regions of space which it is proposed to illuminate. The arc is more steady, and the position of the surfaces is more advantageous where the incandescence is greatest; these are the advantages which are procured where a very small jet of oxygen is directed upon the carbon. It offers some inconvenience to the elongation of the flame produced, by the impurities contained in the carbon ordinarily employed, and I again repeat, that all the improvements which can be, in this manner, produced in the electric light, are intimately connected with the production of carbon as pure and cohesive as possible.

The Electric Light as Supplied by Magneto Electrical Machines.—Translated from *Les Mondes.*

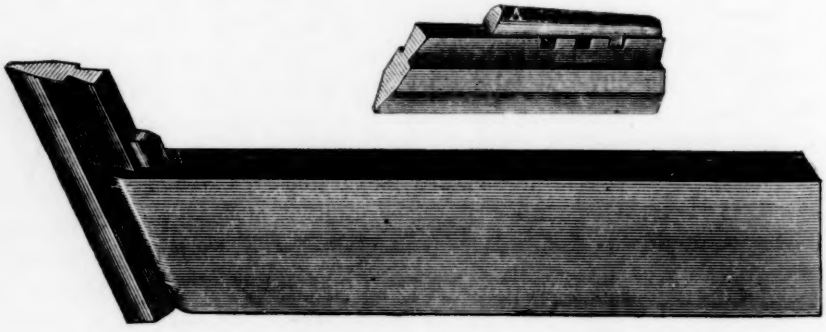
Messrs. Jamin & Roger have published an account of some experiments on the electric light, recently made with a magneto electric machine in the physical laboratory established at the Sorbonne, placed there by the *Alliance Company.* It is well known that during one turn of this machine, sixteen currents are produced alternately, in opposite directions, and necessarily separated by a state of repose. The light that this machine produces must then be discontinued sixteen times during each turn. It is of this intermittance that we now wish to give proof. We have fixed at the end of an axle a silvered mirror capable of turning, and placed at an angle of 90°. The light is thrown upon this from an electric lamp of Foucault's pattern, supplied by a magneto-electric machine. The rays are concentrated by a system of lenses, and being reflected by the mirror, are cast upon a screen, where they produce the image of the carbon points. That image describes in the same time as the machine, a

circle of light, in which the light appears persistent on account of the rapidity of the movement (500 turns per minute). If the mirror was fixed, the image showed two carbon points one above the other, separated by the arc. As it is moved, the carbon points describe upon the screen two excentric circles, separated at the top and bottom, and intersecting at the extremities of a horizontal diameter; the image of the violet arc is visible only at the top and bottom. One might expect to see sixteen arcs illuminated at the moment of the current's passing, separated by sixteen obscure parts the moment it changes its direction, but it is not so. The image is continued; only there is a slight augmentation in the brilliancy of the violet light of the arc in sixteen prominent positions; while at sixteen other positions the carbons are a little less brilliant, and the arc diminished. The image of the upper carbon was always the more vivid.

The increase of the luminous intensity shows itself alternately at the top and bottom, as it ought to be, when the currents change their sign.

All this might be predicted. That which appears nevertheless to merit attention, is, that the light of the arc is very small as compared with that which is emitted by the carbon; that which supplies the light during the cessation of the current, and to which the light is chiefly due, is the high temperature to which the carbons are brought.

A New Lathe Tool, by Shaw & Justice, of this city. We have at various times called attention to improvements in tools, and espe-



cially to the plan of separating the cutter from the stock, by which the great loss of material and time occasioned by upsetting or dressing on the anvil, is avoided.

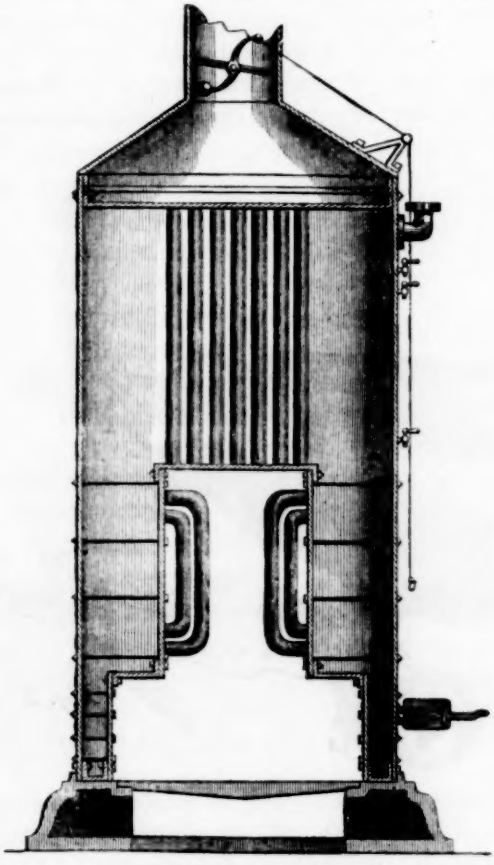
We now give in the accompanying cut, a full view of a new plan for accomplishing this end.

Below is the stock with cutter in place; above, the cutter removed from the stock.

Explanation is hardly required, for anything so self evident as the connection or action of these parts. The cutter is evidently kept in place by the conical wedge, which is secured to it by the sort of tooth and rack adjustment shown; as the tool wears away, it is set higher up by setting the tooth of the wedge back to a further recess in the cutter.

The advantages of the arrangement will be evident to every practical machinist at a glance.

The Excelsior Steam Boiler, invented by H. T. Fenton. This boiler, whose mode of construction and general principle of opera-



tion are manifest on inspection of the accompanying cut, is intended to obviate two of the most serious faults met with in most tubular boilers, namely, incomplete combustion, and imperfect circulation.

The first, it is claimed, finds a remedy in the large combustion chamber provided below the tubes, and the latter is secured by the special arrangement of the tubes shown in the cut, where it is manifest that a rapid up-draft of the heated water and steam will occur in the central portions, an opposite current being established on the outside.

Glycerine.—The various uses to which this substance is now applied in the arts, has given rise to competition in its manufacture in this country, and it is now manufactured as pure as it can be imported, and at one-half the cost. In commerce, two qualities of glycerine are found, one of which, applied to irritations on the skin, acts as a salutary balm, while the other, *causes* inflammation and irritation. Recent chemical analysis has shown that the last effect is due to traces of formic acid, and sometimes of oxalate of ammonia.

A Combined Low Water Indicator and Water Guage, exhibited at the Monthly Meeting of the Franklin Institute, March 18, 1868, by the Patentee, J. D. Lynde, of 37 N. Seventh St., Philada.

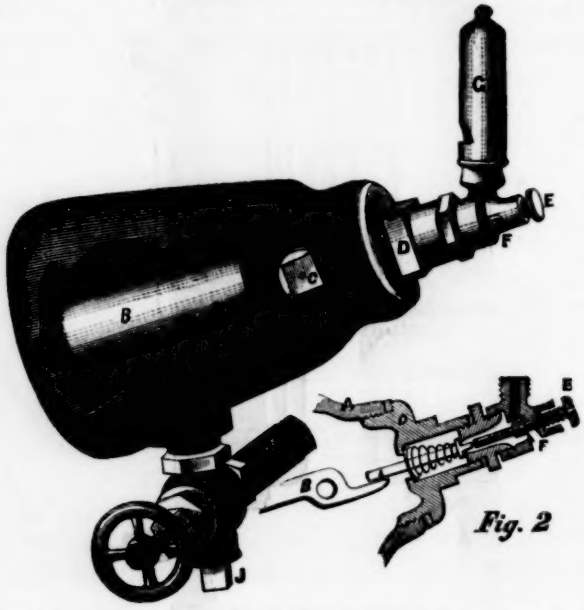


Fig. 2

The special merits claimed for this instrument are as follows:

1. Certainty. 2. Simplicity. 3. Durability. 4. Self-detection. 5. Ease of testing. 6. Incapacity to deceive.

These points were explained as follows:—

1. There is no possibility of the working parts sticking from corrosion, as they are daily used as a water-gauge, and consequently are always free. There is double the power required to work the valve, thus placing it beyond a doubt that it will operate *automatically*, as stated.

2. An examination of the cut will show its simplicity. It can at any time be taken apart in a few minutes, and examined for cleaning or repairs.

3. The parts are all made with a view to strength and durability, as an examination will show.

4. It is a self-detector, because, should it get out of order in any possible way, it will show it at once, and require attention.

5. Should it be desired to know if the instrument is in working order, the fact can be ascertained as follows: Shut it off from the boiler, and draw the water from it by unscrewing the plug at bottom; as the water falls out, the valve will be discovered to open, proving it would do the same should the water fall out into the boiler. Close the aperture again, and let in the water. The valve will be observed to be open at first, but as the case fills, it will be found to close automatically, proving that the float has risen to the top of the case.

6. Above all, it will never deceive, as from its construction it must be in *working order*, and faithfully perform its duties, or it will show itself *out of order*, and need attention.

It is believed that this is the only detector which can be employed on a locomotive.

Experiments with Sound.—Some interesting experiments in acoustics are translated in the *Scientific American* of a recent date. M. Regnault, of the Institute of France, has been conducting some experiments in the new sewers of Paris, for the purpose of testing, on a large scale, some questions in acoustics, concerning which there has been much doubt.

By firing a pistol in the sewers and in tubes of various diameters, he found that the sound was transmitted through the following distances: In a passage of 4·2 inches diameter, 1282 yards; in a passage 11·8 inches diameter, 4191 yards; in a passage 43 inches in diameter, 10,494 yards. The rapidity with which the sound was transmitted, depended greatly upon the construction of the passage. M. Regnault also discovers that sounds of different pitch are not propagated through these tubes with equal rapidity, but separate

from each other on the way. This fact is a new one, requiring study, and experiments are needed to enable us to discover its true reason. We are inclined to believe these results arise from an interference of the waves, and not from the different velocities of sounds of different pitch.

A band of music heard in the open air, at a long distance, still yields a harmony, which shows us that the notes do not reach our ear with a velocity corresponding to their pitch in that case.

Sulphite of Magnesia.—In the last number of the *American Journal of Pharmacy*, we find a very good article on the production of the above substance. This salt has not heretofore received any especial attention, but recently having come into request, a search was made in all the authorities for a formula for its preparation. The only formula appearing, was one from Wittstein Jahresschrift, as follows: "Sulphite of Magnesia may be prepared by passing sulphurous acid gas through water, holding carbonate of magnesia in suspension; but the salt thus obtained was not quite white."

"A better way is to dissolve 136 parts of crystallized sulphite of soda, free from carbonate and sulphate, in the smallest quantity of hot water, and to filter into this hot liquid a concentrated solution of 123 parts of Epsom salts, the mixture to be stirred until cold. The mass of fine crystals which form are allowed to drain on a strainer, then pressed and dried at a moderate heat. The product should weigh sixty-nine parts."

The sulphite of soda of commerce is often contaminated with sulphate and carbonate, and if the sulphite was not pure, the yield was diminished in proportion to the impurities contained in it.

The following is the average result of several experiments made by Mr. J. P. Remington, of Brooklyn, and represents about what the results would be in ordinary practice.

Five grammes of Jennings' magnesia (re-calcined), was made into a thick, smooth paste, with ten c. c. of distilled water; to this was added slowly, with stirring, 102 c. c. of aqueous sulphurous acid, sp. gr. 2,037. The liquid on the surface now showed an acid reaction, and had a yellow color; after standing a few minutes, the supernatent liquid was decanted; the crystals were then placed on a tarred filter and washed with distilled water, until the washings came through colorless. The filter and contents were then dried, and weighed 15,310 grammes, which was 306 times the weight of the magnesia used, or

306·2 per cent.; the theoretical yield should have been 3·95 times the amount of magnesia.

The sulphite of magnesia obtained was in small, white crystals, resembling in taste the sulphites, though not so disagreeable as the sulphites of soda and potash, on account of its insolubility. The process was then tried on a somewhat larger scale, with success, but the minutiæ so nearly resembled the former process given, we do not consider it necessary to repeat it. The yellow color seems to be caused by an impurity soluble in sulphurous acid (believed to be iron), and, as it only appears when the acid is in excess, is a good indication that the magnesia has all been acted upon.

By this process, sulphite of magnesia is obtained as pure and white as by double decomposition, with economy in the most valuable items—time and labor; the yellow color all disappearing by the simple process of washing, the loss by washing being small, as the salt is with great difficulty soluble in cold water.

Metallic Cerium has lately been prepared by Wohler, in globules of fifty to sixty milligrammes, by the ignition of the double chloride of cerium and potassium with sodium. Cerium when cut and polished, possesses a strong lustre; its color is between that of iron and lead; its specific gravity is 5·5 a 12° c. At the ordinary temperature it slowly tarnishes, while at a high temperature burns explosively, throwing scintillations. At a moderately high temperature it decomposes water slightly, giving off hydrogen.

Sale of the Late Paris Exhibition.—The iron portion of the buildings in the Champ Elysées, has been sold to a company of contractors for the sum of $300,000. Its future destination is not yet known.

Coal in Italy.—Coal bearings have recently been discovered in Italy, and attempts are being made to work them by means of a joint stock company. The government has ordered fifty tons of coal from the new company, after the completion of certain preliminary experiments.

The Prevention of Mistakes on Telegraph Lines.—In the Hughes system, which is so largely in use, many mistakes are liable to occur, sometimes through accident, more often by fraud. The strip containing the message is gummed to a piece of paper, from which the despatch is sent, and can be easily detached and altered. In order to prevent this, the French government have very recently introduced an ingenious method of rendering absolute safety. The

despatch after being gummed upon the paper, is passed between rollers having any desired pattern, these impress themselves into the paper, and of course prevent any tampering.

Philosophical Jewelry.—We see in *Les Mondes*, a description of a curious invention of M. Trouvé, a clock maker, who has employed electricity in connection with jewelry. The designs shown are scarf pins and brooches, and are worked by small batteries which are carried in a box in the pocket.

Among the most curious is a rabbit, which beats with two drumsticks alternately on a bell; a skeleton head, which moves the eyes and opens the mouth; a grenadier beating a drum; a monkey playing a violin, and a bird, composed of diamonds, whose wings and tail move as in the act of flying.

The batteries used are very minute, and consist of pieces of zinc and platinum, or zinc and carbon, fastened to the lid of the box, while a saturated solution of the acid sulphate of mercury occupies the bottom of the box. When the box stands upright, the elements do not reach the liquid, but when it is inverted or is placed on its side, the action commences, and is communicated to the figure. In the case of the rabbit, the motor is an electro-magnet with a bracket, on which the armature is jointed, a little spring raises the armature, and the commutator, which is on the opposite side, is so arranged that when the armature touches it, the current is interrupted until it returns to its former position, when it is again attracted in the same way. In this way, simple reciprocating action is obtained, which is easily communicated to the arms of the rabbit, causing one to ascend while the other descends. In a similar way, the other figures are caused to move; but for a detailed description of their various arrangements, we must refer to the article in *Les Mondes*.

Ventilation.—We were told a few days ago, of a very singular occurrence, which illustrates the fact that even fish know the inconvenience of want of ventilation. A pond in the country was suddenly frozen over without any air-holes, and the fish soon breathed out all the fresh air contained in the water; when some persons chanced to cut a hole through the surface, the fish immediately congregated to it in such numbers and with such eagerness, that they could easily be picked out with the hand.

Transparent Gelatine Prints.—At the last meeting of the Franklin Institute, there was exhibited by Mr. Alex. E. Outerbridge, Jr., some transparencies for the lantern, of a novel and effec-

tive description. They consisted of impressions from wood cuts, made upon sheets of gelatine *directly from the cut*, and with as much facility as upon ordinary paper. Mr. Outerbridge has since found that the *finest lithographs* may be taken upon this substance with the greatest readiness. The only precaution necessary is to print with a dry stone, since gelatine is very soluble in water. The gelatine may be made insoluble by mixing with it while fluid, a small quantity of bichromate of potash and then exposing to light. This, however, slightly tinges the otherwise perfectly transparent substance. We have in our possession an impression on gelatine, of the map of the Suez Canal, to be found in our last Number. The finest lines and dots appear perfectly, and with more density than could be obtained in a photograph. This opens quite a new and extensive field for lantern illustration.

Novel Filters.—Among the novelties exhibited at the last meeting of the Institute, were shown by Professor Rogers some very ingenious filters, brought by him from Paris, consisting of a hollow block of very porous stone or coke, closed by a cork, through which a glass tube, connected with one of India rubber, was inserted. The stone being sunk in the solution which it is desired to filter, and the air being drawn out by the mouth from the other end of the tube, the water or solution then syphons over, and most of the impurity is arrested by the porous substance. It has since been shown by Mr. Alex. E. Outerbridge, Jr., that a like instrument may be produced if we take an ordinary carbon cylinder (a broken piece will answer perfectly), such as is used in the Bunsen battery, and insert a cork in either end of the hole which passes through it, and at one end attach the India rubber tube as before. This form is much more effective than the French syphons, since the carbon is more dense, and therefore arrests the finer particles of mud which escape through the pores of the more open stone or coke used in the French filters. The rate of filtering is of course, however, slower.

Platina in Oregon.—A very fine specimen of platina was lately exhibited at the meeting of the "Lyceum of Natural History" in New York, by Professor Chandler. This specimen was brought from Oregon, and weighed over four pounds.

Editorial Correspondence.

BRIDGE CONTRACTS.

NEW YORK, *April*, 1868.

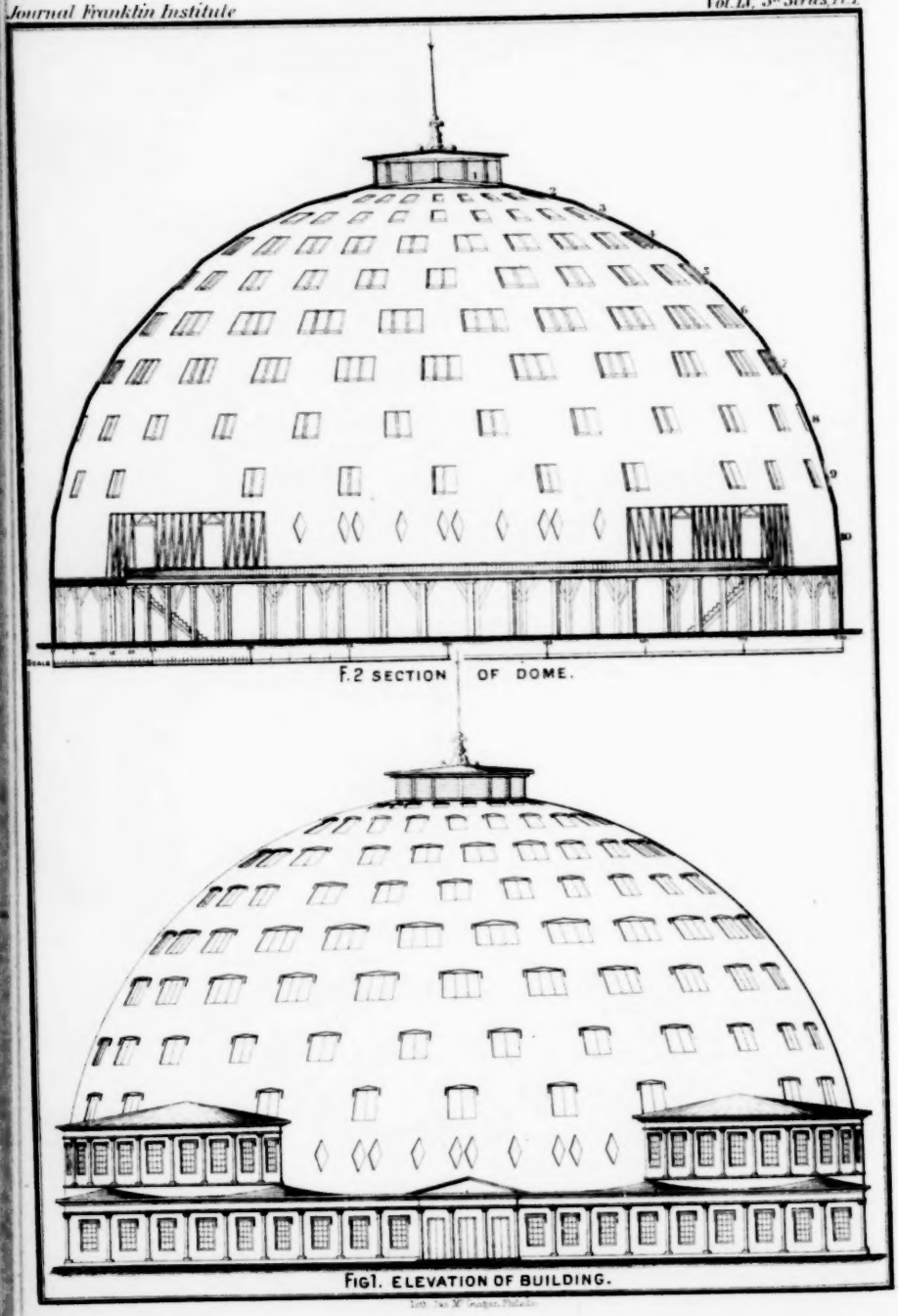
THE last two or three years have been remarkable in the engineering world for the great number of large and important bridges that have been begun, and the coming years seem to indicate that very many more will be required to meet the increasing demands of commerce. The West, having the experience of the East for a precedent, is wisely erecting those structures of iron, and the East in turn will replace the gradually rotting superstructures of her railroads with iron ones, being guided by the experience of the West. I do not propose to advocate "iron" as against "wood" as a constructive material, but I do propose to indulge in a few remarks respecting the pernicious practice indulged in by most railway corporations, in the matter of "Bridge Contracts," and more particularly regarding contracts for iron bridges. When an important bridge is to be constructed, the usual custom is to appoint an engineer, who, after examining the ground and selecting the most favorable crossing, advertises in the name of the company for proposals for masonry and superstructure. Of the former, I will say nothing, but concerning the latter, the engineer is rarely competent to design, or even select one as better than another. The consequence is, that the contractor presents his own design with estimates for work, knowing at the same time that the award will be based upon the question of dollars and cents alone. So long as human nature is weak, the temptation to err where money is concerned, is very great, especially in "lumped contracts," and the contractor is tempted to secure the work by reducing the ratio of the working to the breaking load of his bridge to a risky, not to say unsafe degree, but also to buy his iron where he can buy cheapest. It makes a marked difference in a bridge whether one party's bid is based on a ratio of one to four, or one to six, for his working and breaking loads; and when a bid is made upon a basis of a low ratio, coupled with poor iron, we have what insurance companies would call an "extra hazardous risk." I do not say this is so, but I do say that the *tendency* is in this direction, and will be so just as long as railroad companies advertise indiscriminately for a bridge

that they may need, and accept any plan that may be presented by a contractor that costs the least. How are they to know that their bridge is properly proportioned in general design, or the carrying out of detail? 'Tis true that they provide a certain test load before accepting a structure from the hands of the contractor, but what does that show in regard to endurance? Mr. Fairbairn's recent experiments upon the import of girders, most effectually show that we must not draw our conclusions from the effect produced by a load a *few times* imposed, but from the *prolonged* action of a changing load. They ask also that their wrought iron should not part under a tensile strain of 60,000 pounds per square inch. So far as this will secure good and suitable bridge iron, they might as well say nothing about the quality of iron. Perhaps there is no material that is more sensitive to variation in manufacture than this essential element of civilization. Its grades, whether cast or puddled, are as different as the furnaces, at which each may be manufactured, dependent on ore, fuel, and method of working. Too much care, therefore, cannot be exercised in its selection for the various purposes for which it may be employed. To most people iron is iron, and an iron bridge is nothing more than its name implies, and one is as good as another. But the metal of which it is built may be cold, short, or red short, common or refined, or all, depending upon where the contractor (who has, nine times out of ten, full discretionary powers as to design and material), could buy his iron the cheapest. That this system is wrong in its tendency, promising disastrous results to life and limb will be apparent to any reflecting man, and unless corrected we will one day have a serious list of disrupted bridges all over the country, which will naturally carry a popular condemnation of iron as a material for bridge superstructure, and a clamor to return to the old perishable wooden constructions. There is but one way for a railway company to secure a *good* iron bridge, and that is to separate contractor and engineer, and have their work designed in all its detail, with rigid specifications as to material, by an engineer engaged and paid for such service, as well as to superintend its erection. Contractors should *all* bid on the *same* plan, which is fair and equitable to each and every one, and the lowest *responsible* bidder can freely be given the work, with every assurance of satisfactory results. Without some such division of labor and responsibility, it seems to me that a direct bid is made for dishonesty, which reacts not only on the parties themselves (for which no one would care a rush), but also

imperils the lives of the traveling public, and brings the only proper material for permanent work into disfavor, resulting in its disuse.

Iron, in its various conditions, suitable for various circumstances, is the surest material we can build with, but as before noted, a simple provision in a specification for an extreme breaking limit means nothing. The value of an iron bar in *tension*, is not measured alone by the original unstrained cross-section, but also by the area of the *contracted* section *after parting*, and he who takes the trouble to consult Mr. Kirkaldy's experiments made for the Messrs. Napier, about 1860, will see the importance of this. A high limit, merely shows that the iron is very highly refined, very fibrous and ductile, as in charcoal irons for wire purposes. Lead or copper take a certain strain to part the fibres, which strain is greatly in excess of that when the metal *first* begins to stretch. The moment that point is reached, it is practically gone so far as its further value is concerned. The strength of a metal is reached at the point where the fibres, or molecules, or whatever you choose to call them, refuse to regain their unstrained position. In other words, the point of *permanent set*, inside which limits we can work it with perfect impunity up to one-half or two-thirds (according to service to be performed), the number of pounds or tons causing that permanent set. So that iron should always be specified for its *permanent setting* limit, and not its parting strain. Iron of 60,000 pounds, or over, parting strain, may have a "setting limit," far below an iron that may part at 50, or 55,000 pounds to square inch, and therefore inferior for bridge purposes. I have instanced lead and copper as one extreme, and I now instance steel as the other. Instead of being soft and fibrous, steel is (as compared with iron), hard and granular, and hardly takes a permanent set until almost at its parting strain, and the harder the metal more nearly do these points approximate, until we come to the cast metals, where there is an inappreciable difference between the sectional area before and after tension. Facts like these, familiar as they are to the best iron manufacturers, do not seem to be known as universally as they ought, or if known, they are not acted upon by those who use the material. Far be it from me to accuse railroad presidents and directors of possessing such fundamental knowledge; but they should possess themselves of it, and they would soon understand how an iron bridge may be as unsafe as a boiler, when of bad design and material, which may last and do apparent good service for a few years, and then unaccountably collapse or explode, killing or maiming everybody within reach.

Journal Franklin Institute Vol. IV. 3d Series. Pl. I.



F.2 SECTION OF DOME.

FIG1. ELEVATION OF BUILDING.

Civil and Mechanical Engineering.

ON THE STRUCTURE OF DOMES.

By Robert Briggs, C. E.

Abstract of a paper read at the meeting of the Franklin Institute, Feb. 19th, 1868.

The conditions of equilibrium and stability of domical structures, was the subject of an address at length, with models, diagrams and sketches, by Mr. Robt. Briggs. The following is an abstract of his remarks:

The necessity of providing a suitable building for the proposed exhibition of the Franklin Institute, which should be of large magnitude, to answer the first demand of *purpose*, and of simplicity of construction, with the least material and with that material comparatively uninjured for future use, to fill the second essential *cheapness*, led the speaker to study the availability of a wooden domical structure to ascertain if it were practicable to erect a single dome which should at one span cover the space placed at the disposal of the committee. This space is an area of 208 feet square, within one of the Penn Squares, and the speaker had studied a building consisting of a first story, square in plan, but with a rotunda 208 feet in diameter, constructed within the square, from which a single dome without chords or ties should rise. At the base of the dome would be a gallery of twenty feet width all around the rotunda, and in the corners of the square would be semicircular additions of sixty-one feet diameter upon the level of the gallery floor. The whole giving an area of about one acre on the ground and one-third of an acre upon the second floor.

Figs. 1, 2 and 3, show the elevation, section and half-top view of the proposed building, and Fig. 4 shows a half-top view of the frame-work proposed.

Of course the problem which was to be considered, after devising some detail of construction suited to the magnitude, was the stability of the structure.

The construction proposed after rising upon a collonade to the level of the gallery floor (the strength of which could be readily determined when the load of the dome above was known), was to

form a tie-band of boards super-imposed (four layers of one-inch boards being assumed as the method of forming this tie-band), upon which should be stepped the ends of a series of rafters sixteen feet long, three by ten-inch joists; above this would be placed a second band same as the first, and again the second series of rafters would rise from this tie-band similar to the first series. This procedure would be followed ten times, until the tenth series of rafters would meet at the apex of the dome.

The questions then to be solved, was first, the shape most suitable to give this domical structure; and second, after deciding upon any particular shape, to calculate or ascertain the strains upon the tie-bands, and their capability of meeting them, and so far exceeding them as to afford the conditions of stability desirable.

As regards the form, it was possible to take one form which should be so proportioned that no strain should come upon the tie-bands at all, either outwards or inwards, except for the bottom tie-band of all, or some abutment, and any strength or rigidity they should possess, would be the limit of stability of the dome.

Or another form could be that in which the tension upon each tie-band could be made equal, so as to divide the pressure upon all the bands, and not transmit any strain to an abutment.

The adoption of some definite shape, some surface of revolution, ellipsoidal, spherical or similar form, and then to calculate or ascertain in some way, the strains existing at various points of the dome, would be a third way of considering the problem.

In the proposed method of construction, it would be evident that any regular figure possessing uniformity of condition of strains at each and every point, is not to be considered, but that the belts or zones of rafters with circumscribing tie-bands above or below, resolve the problem to one similar to that of a rope loaded at points, in place of that of a cord uniformly loaded. Still it was proper in this part of the discussion, to assume that the uniform load and distribution of strains existed; as the outline of a section of the dome, would in one case be points in a true curve, and in the other the curve itself.

Taking the first form, that of a dome of equilibrium, with the strains upon all the tie-bands, except the lower one, balanced, we have the shape known as a transformed catanery.

The catanery proper is the form of a cord suspended freely from

two points, and is that of a suspension bridge or arch, without load, where in the latter case the parts are in perfect equilibrium (and instability), and the entire thrust is transmitted to the abutments. Whatever portion of the same catanery be taken, the horizontal component (or the thrust in case of an arch) is constant.

The transformed catanery which gives the contour of a dome of equilibrium, differs from the ordinary catanery, in that the load upon the chain in place of being uniform, varies as the weights (or areas of surface) of zones of the dome. Like the catanery of a plane, this domical catanery has a constant horizontal component, each and every part of it when considered as composed of pieces made like the stones of an arch, being balanced so far as the tendency to fall in or fall out is concerned, and the entire thrust or unbalanced horizontal component is transmitted from zone to zone to the base of the dome. If we suppose an arch or suspension bridge, it will be recognized that unless we consider the arch-stones or the suspending cord to be a beam, we must expend the thrust of the arch or strain of the cord upon abutments or ties, or upon anchors or straining pieces, which can be most economically and satisfactorily applied at the lower portion of the arch, or the upper one of the cord; but with a domical structure there is nothing to prevent, where it is desirable or practicable, to take up the strain upon bands; using these bands in any portion of the domical surface where strain subsists.

This last proposition leads directly to the second form suggested, that is, one where the unbalanced pressure would be equally divided in all the bands (and if we could suppose the dome to be in perfect contour, the base would rise with a vertical tangent without thrust).

But there are two or three objections to both these shapes; they are very flat upon the crown, so flat that with the least yielding of the material from compression or elasticity, the bearing surfaces of the upper one or two sections, would be impaired, and the whole structure be imperilled—The second form suggested is very open to this difficulty. Again, they have such irregularity of curvature, that it would be difficult to lay out the joints, as each zone differs essentially. Above all, they are very ugly in contour, having neither grace or appearance of repose, which is perhaps the only term by which the evident want of stability beyond the tie-bands or skin can be named. . . . . These considera-

tions, with others which were stated, led to the adoption of a hemisphere as a basis for the plan and investigation, and it remained only to devise some approximate means for determining the amount of the various strains upon the polygonal shape which was assumed to construct the hemispherical dome. The data, so far as weights of parts was concerned, could only be approximate, and the information desired as to the strains was also only such an approximation to the actual forces, as would allow a decision of the compatability of the parts with coefficients of safety much greater than any chance of error from the uncertain data or the inaccurate calculations or experimental results.

*The speaker alluded to the difficulties of computation, and the chances of error which lay in considering, as a mathematical problem, these applications of forces to structures, and exhibited a model which had been made to show graphically the results within the limits of accuracy needed. Fig. 5 shows a view of this model.

This model consisted in a chain made of twenty-two links of brass, each four and one-twelfth inches long (sixteen and one-third feet to the scale), delicately hung with little friction at the joints. This chain was suspended freely in front of a drawing-board, upon which was described a semicircle of four feet four inches diameter, the centre line passing through the first joint of the chain, so that twenty of the links hung in contiguity with the semicircle. To each of the links near the middle of its length, where the centre of gravity of the material of the zone which the link represented, was found by inspection and calculation to come, was suspended by a fine wire a weight, which weight represented $\frac{1}{10000}$th part of one-half of the material comprising the zone of the dome. When thus loaded, the ratio of the total weights to the weight of the chain supporting them, was so large that the influence of the chain-weight upon the curve (or polygon strictly speaking) could be overlooked, and the line obtained approximated very nearly to that of equilibrium of a dome composed of conical frustra under the conditions assumed.

If the dome were to be constructed in this shape, the horizontal components at each intersection of the frustra would balance, and

* It is perfectly easy to compute the strains from the data assumed, in place of obtaining them approximately by a model, but the speaker presented the model as better suited for appreciation to a general audience.

that at the base would be represented by the force needed to draw the upper link into a vertical condition. In the model this force was measured by means of a bell-crank lever, connected by wires to the joint from one end of the lever, and dependent from the other end was placed a weight which counterbalanced the force. The shape of this approximate catanery and the amount of its horizontal component (or parameter) was shown at the meeting. The table which completes this article, gives all the weights employed and results obtained.

In a similar way, by a system of bell-crank levers, the strains which would exist in a hemispherical dome, were resolved into vertical and horizontal components. Each joint in the chain was drawn by a weight into the circle of the hemisphere. The weight required to perform this representing the plus or minus horizontal component, the tension or compression of each tie-band at any point of its circumference.

The following table gives the weight ascertained as that of the separate zones, and the horizontal components which the model exhibited; while the third column shows the strain upon the tie-bands, the + indicating compression, and the — indicating tension.

APPROXIMATE HEMISPHERE.

No. of Zone, commencing at crown.	Half weight of timber and skin of each zone.	Horizontal Component ascertained.	Strain on tie-band.	Total Horizontal Component when the approximate catanery was obtained.
1	2,370 lbs.	0	0	44,200 lbs.
2	5,920	+12,000	+3,910	
3	10,450	+12,000	+3,910	
4	13,890	+ 6,400	+2,040	
5	18,080	+ 3,700	+1,180	Total strain on tie-band at abutment. 14,090 lbs.
6	21,110	0	0	
7	24,850	— 8,500	—2,710	
8	29,550	—17,000	—5,410	
9	32,670	—19,300	—6,140	
10	35,550	—14,300	—4,550	

As the weights applied as vertical components by suspension from the links were taken at $\frac{1}{10000}$th part of each balancing half of the total weights of each zone, the horizontal component obtained by experiments could be taken as the force exerted radially upon the tie-band for $\frac{1}{10000}$th part of its circumference, or as so much internal or external pressure applied to the tie-band. The tension or compression on the tie-band consequently was as the ratio of the diameter to the half circumference $\left(\frac{2}{\pi}\right)$, which tension or compression being resisted by both sides of the band, the strain tending to rupture or crush the tie-band, was related to the horizontal component found as $\left(\frac{1}{\pi}\right)$.

The other strains to be resisted in the structure are: that of compression along the rafters; that of the weight of the rafters and skin, which is applied to the rafters as a load upon a beam; and that of the twisting moment which may proceed from some current of air blowing unequally along one side or whirling around the structure.

The strength of the rafters to sustain the load applied to them endways, is too greatly in excess to need question. Their strength as beams supported by their end tie-bands as abutments, is that of ordinary roofs made to carry snows, and intended as permanent structures, the lengths and spaces between being the same.

The arrangement of the rafters incident to the application of the load proceeding from each rafter upon the ends of one or two rafters in the zone below it, gives a system of triangular braces presenting great rigidity. This arrangement may be understood from the following description of the three upper zones: The topmost circle is framed with twenty-four radial rafters stepping on the upper tie-band, the next zone has forty-eight rafters arranged in pairs, the upper ends of each pair supporting the lower ends of the first rafters, and spread at the foot in the form of a letter A, so that between the twenty-four A's, are left spaces with parallel sides for twenty-four windows. The next zone has the rafters similarly arranged, only that under what forms the window spaces in the zone above, the rafters brace like letters M, there being window spaces between each M. Of course these braced triangles

FIG 4. HALF TOP VIEW SHOWING FRAMING

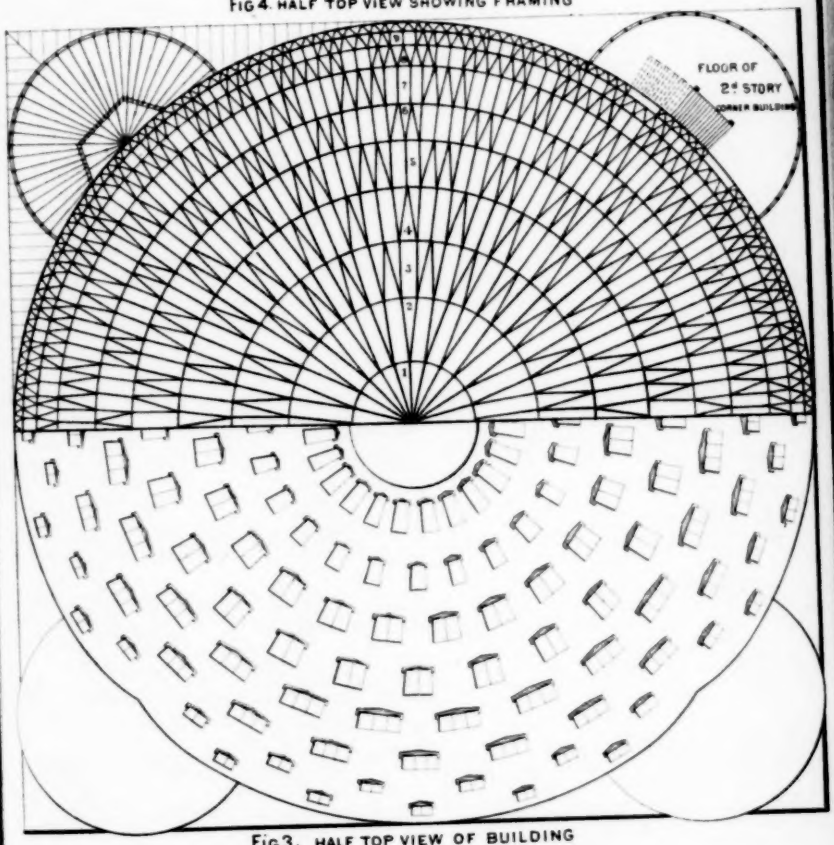
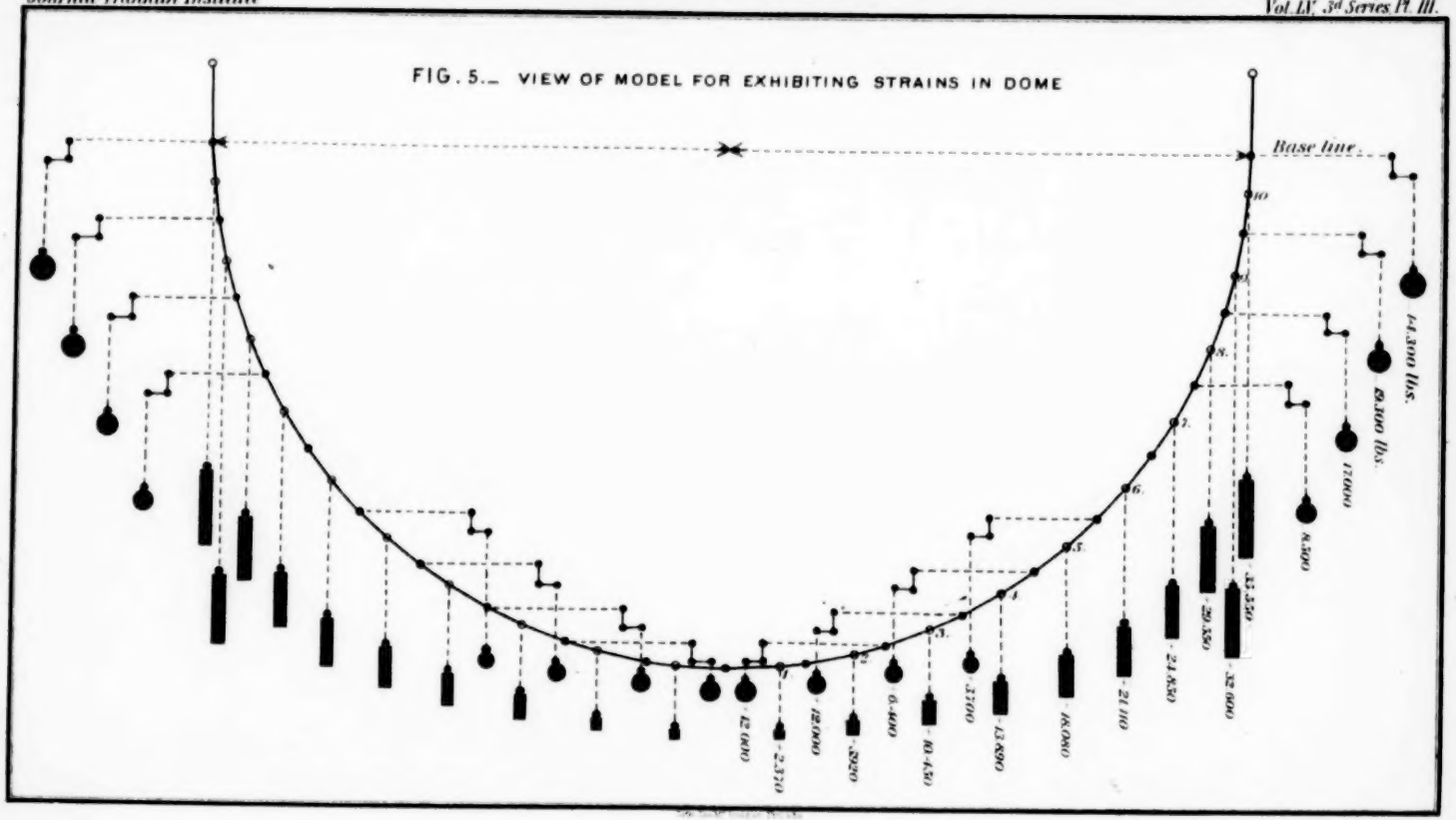


FIG 3. HALF TOP VIEW OF BUILDING

Journal Franklin Institute

Vol. LV. 3d Series Pl. III.



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could not be racked except by a force largely in excess of any likely to be brought against the dome.

The strength of the tie-bands, which are subject to tension, is derived from the ultimate strength of the wood, say 12,000 pounds per square inch, and by the value of the co-efficient of friction under the loads of weight and thrust. If we take the lower section, for instance, we have in weight about 1000 pounds to each rafter, and there are two rafters to each three feet space, this gives on the sixteen feet length for the tie-band boards, 10,700 pounds load. The friction of wood on wood is quite one-half the weight, where the surfaces are not specially smoothed, and are compressed together so that the contact is not one of points (or splinters). And there are three surfaces of contact (at least), this would show the tensional strength, as derived from the friction between the boards composing it of the lower tie-band, to be from weight alone, 16,000 pounds. The nailings would add to the frictional hold, and the vertical component also aid in consolidating the tie-band. As regards the ultimate strength of the tie-band, it is enormously in excess of any demand. Taking knots, cross-graining and the ends into account, it will be safe to assume that one-half the tie-band, or ten inches by two inches, or twenty square inches section, is sound solid timber, and taking this at one-third ultimate strength, we have 80,000 pounds as the reliable strength.

The discussion of other tensionally strained tie-bands, or of those subjected to compression, would lead to similar results. So far as resistance to winds is concerned, the following considerations may be entertained.

The weight of the dome as proposed, would be about six pounds per foot of surface. From Fresnel's experiments, it would appear that a dome offers about one-third the resistance to wind, that a vertical plane surface presents. Our heaviest wind can be assumed in gusts at eighteen pounds per square foot. The effect upon the dome would be six pounds per foot of section exposed in the direction of the wind.

Reducing this to a pressure all over the surface uniformly distributed, the load is three pounds per square foot, and the effect upon the tie-bands is to increase their strains of tension or compression one-half. But supposing this force is considered as applied, so as to distort, flatten, or *blow* in the dome side, the effect upon all the

parts would be more complex. Rafters must crush—bracings must yield—tie-bands must collapse or rend—it would seem that an absolute disintegration, not of the structure into pieces, but of the pieces themselves, must occur before any catastrophe could ensue.

The capability of the whole structure to resist a wind which should move it sideways, can be also demonstrated. Its weight is 400,000 pounds on the first tie-band. The heaviest gust supposable, would exert a force of one-third of eighteen pounds upon 34,000 feet surface, or 200,000 pounds. This would be almost exactly the frictional hold upon a smooth surface, but when the nailings and other sources of adhesion are considered, this ground for alarm disappears.

The strains upon the structure when in process of erection, should not be overlooked. It being needful to demonstrate it could be built as well as that it would stand. After each section is raised and the tie-bands at the upper ends of the rafters attached, it is obvious that the greatest strain to be carried is the tendency of the upper ends to fall inwards, which is to be resisted by the compressive strength of the upper tie-band.

[The lower tie-band of any zone is in all cases only subject to that difference of strain (plus or minus) which exists between the outward thrust of the last section, and the inward thrust of the one below it.]

This tendency can be estimated; for we have the weight of the section W, and the angle a, at which the rafters stand, and H (the horizontal component) = W tang. a.

By computation, the greatest compressive strain will be on the eighth tie-band, and = 8000 pounds, which it is abundantly able to carry.

Exteriorly, such a building as proposed would not present striking or graceful architectural features, but within, the expanse would have that grandeur which proceeds from magnitude, and that beauty which comes from apparent lightness. The building would prove an instructive and remarkable portion of our proposed exhibition.*

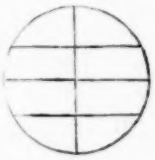
* Although the exhibition itself has been postponed this year, and it is almost certain that this plan would not have been followed, as another less novel and less costly, from its want of novelty, was proposed, it has been thought if not immediately productive, that this study may have some interest.

TELESCOPIC MEASUREMENT IN SURVEYING.

By Benjamin Smith Lyman, Mining Engineer.

Read before the Franklin Institute, at the Stated Meeting, March 18th, 1868.

For measuring distances with the telescope, in surveying, the telescope has two or more horizontal cross-hairs besides the ordinary vertical one. In sighting at an upright rod, these horizontal cross-hairs cut off a portion of the rod that is larger or smaller according to the distance of the rod; five times as much, for example, for a distance of a thousand feet, as for one of two hundred feet. A rod graduated to indicate distances in this way, with the help of the telescope, is called a *stadia* by the French, and has been in use some fifty years. In the United States Coast Survey such a rod is called a *telemeter*. The object of this paper is to show that such telescopic measurements in their simplest form are more exact than is perhaps commonly supposed even by professional surveyors; as well as to point out some improvements in the details of the apparatus that add very much to its convenience.

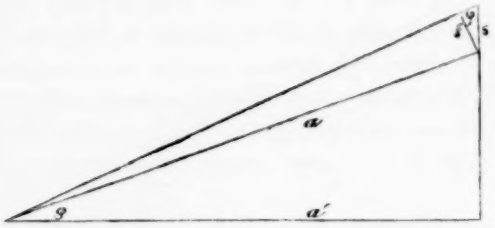


De Sénarmont, nineteen years ago, in the *Annales des Mines* (Fourth Series, vol. xvi.), in a notice of some improved apparatus for telescopic measuring, by Mr. Porro, a Piedmontese, speaks of the stadia as having been used hitherto for rapid and approximate surveys; and gives briefly the theory of its use. If the size of the object seen through the telescope be called s; the distance from the object to the centre of the objective a; the size of the conjugate image of the object, equal to the distance apart of the two horizontal cross

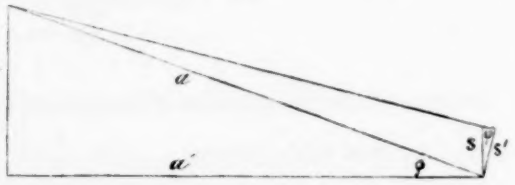
hairs, i; the distance of this image from the centre of the objective x; and the focal length of the objective f: then, $\frac{a}{x}=\frac{s}{i}$. But the general formula of foci of lenses gives $\frac{a}{x}=1-\frac{a}{f}$. Therefore, $a-f=\frac{f}{i}s$; or $a=\frac{f}{i}s+f$. Practically the distance a has commonly been

reckoned so large that the small distance f was neglected, and the formula became $a = \frac{f}{i} s$; in which $\frac{f}{i}$ is a numerical coefficient peculiar to the instrument, and determined by observation once for all. The distances, in that case, are reckoned proportional to the space cut off on the rod, counting from the centre of the instrument, whereas they ought strictly to be counted from a point as far in front of the objective glass as the focal length of that lens.

In case the telescope in measuring is not level, it is necessary to make besides a double correction; because, in the first place, the space cut off on the vertical rod is greater than if the telescope was sighted level; and, in the next place, the corrected distance of the rod in the slanting direction must be corrected again to give the distance reduced to a level. For if s be the space cut off on the



rod viewed slantingly, and s' the corresponding space when the rod is held square with the line of sight; if a be the distance of the rod from the telescope in the slanting direction, and a' the correct horizontal distance; and φ the angle of the slant with the horizon: then $a' = a \cos \varphi$; $s' = s \cos \phi$; $a = n s'$, where n is the numerical coefficient $\frac{f}{i}$ peculiar to the instrument; and $a' = a \cos \phi = n s' \cos \phi = n s \cos^2 \phi$. It is necessary, then, to multiply the distance indica-



ted by the rod by the square of the cosine of the angle of the sight with the horizon. If, however, account be taken of the necessity, for exactness, of counting the distance a from a point as far in front of the object glass as the focal length (f) of that lens; and also

account of the distance of that lens in front of the axis of the instrument, say d; then, $a' = (a + f + d) \cos \phi = n\, s \cos^2 \phi + (f + d) \cos \phi$. But $(f + d)$ is so small a distance, that with the angles common in practice it differs but a trifle from $(f + d) \cos \phi$, and may be reckoned as the same thing; so that, then, $a' = n\, s \cos^2 \phi + (f + d)$. The quantity $(f + d)$, then, is a small constant, easily determined for each instrument, say one foot or two, that must be added to each level measurement, and to each corrected slanting measurement. Sometimes, when the telescope is not level, the rod is leaned over so as to be square with it; but this is less convenient than the way of correcting just described, for the correction for the slope of the ground has to be made at any rate, and it is extremely easy to make the other at the same time.

De Sénarmont remarks that experince shows that it is possible to subdivide by guess to a tenth a space that subtends an angle of about sixteen minutes. If, then, the rod when magnified by the telescope subtends an angle of about ten degrees, its length could be marked off in forty divisions, and each of them be subdivided by the eye within a tenth. If, for example, the telescope magnified ten or twelve times, like the ordinary ones on transits, for a range of say 660 feet (ten chains or a furlong), then the rod might be something over thirteen feet long, and be marked with divisions a third of a foot long, and then could be subdivided by the eye within a thirtieth of a foot. This limit of exactness would correspond to a foot and two-thirds of distance on the ground, or $\frac{1}{400}$ of the furlong. But if the telescope magnified twenty times, like the telescopes of levels, the divisions on the same rod could be twice as small, so that the limit of error in the reading of the rod would be twice as small also; and the error in the distance on the ground, therefore, would be not more than five-sixths of a foot, or $\frac{1}{800}$ of the whole distance. This, however, is about the greatest exactness that can be obtained in this way with ordinary glasses; since in this case the magnified rod extends about ten degrees in either direction from the focal axis, and more than that the eye-glass cannot embrace without aberrations that are quite too great; so that, if the power of the telescope be increased, the length of the rod and of its divisions must be diminished in proportion.

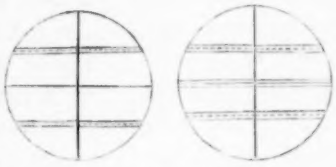
Mr. Porro's improvements, then, aim at an increase of the field, and at the same time of the power; and, besides, the distances are made to count from the axis of the instrument. This last change is effected by placing between the focus of the objective and the cross-hairs an additional lens whose focus is at the same point as

the focus of the objective. The rays, then, after passing the added lens are parallel, and all objects that subtend the same angle from a certain point (*c*) behind the objective (a point which he calls the centre of "anallatisme," that is, of unchangeableness, and whose position is determined by the refraction and distances of the lenses) would have images of the same size, and the size of the objects would be proportional to their distance from that centre. The cross-hairs would, then, cut off a space on the rod proportional to the distance of the rod from the centre of unchangeableness, and this centre may be placed at the axis of the instrument; so that the distances found by reading the rod would be counted immediately from that axis, and if they were not level would be corrected, to get the level distance, simply by multiplying by the cosine square of the angle above or below level.

Then, in order to increase the available extent of the field, Mr. Porro used three eye-glasses, which observed the upper, middle and lower parts of the image; so that the cross-hairs could be put farther apart, and by having an eye-glass opposite each one no error would come from the spherical aberration. But, in order to have a sharp and bright image for these eye-glasses to observe, and yet not need a large objective (which would require a focal length at least twelve times as long as the diameter of the lens to avoid excessive spherical aberration), he used two separate achromatic objectives placed one behind the other, that is, a compound lens, such as had long been used for achromatic microscopes and for cameras. By these means he made telescopes of two inches and a third across and only about fifteen inches in focal length, with a magnifying power of sixty or eighty times; and with the triple eye-piece they enabled him to read distances within at least $\frac{1}{2000}$, and so reduced the uncertainty to less than a third of a foot in 660 feet.

More than that, instead of using simply two horizontal cross-hairs, one above and one below, with or without the middle cross-hair, he always replaced the lower cross-hair by two, at one-tenth the distance from each other that the replaced hair would have been from the upper one, making three cross-hairs besides the middle one. Sometimes also he replaced the upper in like manner by two, making five, counting the middle

one; and sometimes he placed two more just above and below the middle, making seven cross-hairs in all. These additional cross-hairs serve to show that there has been no material error in the reading, and that the divisions of the rod have been correctly subdivided by the eye, and that the sighting is correct when certain divisions are not distinctly visible owing to obstructions. He obtained in this way, with a magnifying power of sixty or eighty times, and with five cross-hairs, and with the divisions of the rod $\frac{1}{100}$ of a foot (four centimètres) long, an exactness within less than $\frac{1}{2000}$ up to a distance of a furlong; between a furlong and a quarter of a mile the middle cross-hair and two outermost ones, gave an exactness of a good deal less than $\frac{1}{1000}$; and between a quarter of a mile and half a mile, one of the outer pairs of cross-hairs, gave an exactness within $\frac{1}{400}$.



De Sénarmont remarks that such a telescope may be advantageously adapted to geodesical, leveling, topographical or land-surveying instruments; but that, applied to the ordinary compass, to the alidade of the plane table, or to the graphomètre, it would give even with a reduced magnifying power a greater exactness than could be obtained with these instruments for the other elements of a topographical projection; and so some of its advantages would be wasted. He admits, also, that the instrument requires extremely nice workmanship, such as few instrument-makers are capable of; and, although it is possible to test the correctness of the different parts, there appears to be no way of adjusting the position of the cross-hairs without removing them from the telescope.

If, however, the number of horizontal cross-hairs be restricted to three, one above and one below the middle one, they can all easily be made adjustable by screws on the outside of the telescope, if the upper and lower hair be placed a very slight distance before or behind the vertical hair, a distance that can give rise to no inconvenience. Observations with the two upper and two lower of the three cross-hairs, (that is, with all three at once) check each other, and if too little of the rod be visible for that, then two successive observations on different parts of the rod, with either one or both pairs, serve the same purpose. In these ways the lack of Porro's additional cross-hairs is very conveniently supplied, except in the sights that are more than a quarter of a mile long. These extremely rare sights, where even his apparatus claims only the indifferent exact-

ness of $\frac{1}{400}$, it is necessary to give up, and make instead two shorter sights with more exact results.

A convenient way of marking the rod with very small divisions removes the fatiguing necessity of subdividing the divisions by the eye to a tenth, and enables the use of a much weaker telescope. According to Plateau, a red disk lighted by sunlight merely reflected by the clouds can be seen distinctly at a distance equal to 6000 times its diameter; according to Müller, at a still greater distance, especially with a favorable background; but with a telescope magnifying twenty times this distance of distinct visibility, becomes 120,000 times the diameter of the disk. It has already been seen that with a simple telescope of that power, the rod can be at most something over thirteen feet long for a range of a furlong; that is, the length of the rod may be one-fiftieth of the length of range. The smallest visible mark on this rod at the distance of a furlong would be not more than $\frac{1}{120000}$ of 660 feet, say $\frac{1}{182}$ of a foot long. A cross-hair, wherever it should cut a rod divided throughout with such marks, would be within one-half the length of a mark from the centre of one of them, or within $\frac{1}{364}$ of a foot of the reading; and this would correspond to a distance of $\frac{50}{364}$ (less than a seventh) of a foot on the ground. This, then, would be the exactness with such a telescope and such a rod, $\frac{50}{364}$ of a foot in 660 feet, or $\frac{1}{4800}$; and for distances between a furlong and a quarter of a mile the exactness would be within $\frac{1}{2400}$. That is more than twice as exact as Porro's large and complicated instrument with his rod less finely divided; and yet requires no larger field than can be got with a common telescope that magnifies twenty times and has but a single eye piece. A magnifying power of ten times with a rod of the same length would give one-half the degree of exactness at those distances; and the marks on the rod must be twice as large, say, $\frac{1}{100}$ of a foot long. At a distance less than a furlong a smaller space on the rod could be distinguished, but it would be the same fraction of the distance measured, so that the exactness would be no greater.

Such small divisions are readily marked on the rod and made easily legible simply by dividing the feet into tenths, and marking each tenth of a foot with an angular figure, whose angles indicate each a division of one-hundredth of a foot. The rod marked in this way can be used for leveling as well as measuring; and the cross-hairs can be adjusted so that one foot on the rod between the middle and upper or lower cross-hair corresponds to a hundred feet.

and the reading gives the distance directly in feet. So adjusted, a telescope that magnifies twenty times uses in measuring just the whole of its available field; but a telescope that magnifies ten times uses only half of it, and is therefore far within the limits set by the spherical aberration of the outer part of the field.

The correction done away with by using the additional lens and reducing the centre of unchangeableness to the axis of the instrument is otherwise made so simply, as already shown, by merely adding to every distance as read from the rod a constant (say, one foot) equal to the focal length of the object glass added to the distance of that glass in front of the axis of the instrument, that the use of those complications seems, on the whole, to have no advantage.

(To be continued.)

THE SUEZ CANAL.

By Chas. H. Rockwell.

(Continued from page 242.)

Through one of these shallow basins, called lake Menzaleh, the canal will be dug for a distance of nearly 30 miles. At the end of lake Menzaleh is another smaller basin, called lake Ballah, about 8 miles in extent, as crossed by the canal, and at the southern side of this is found the highest point of land to be seen on the whole line. The extreme width of this ridge, called El Guisr, is about 10 miles, with a summit 61 feet above the sea level, which, added to 26 feet, the depth of the canal, will require a cutting of 87 feet. On the southern side of El Guisr is lake Timsah, through which the canal will be dredged for about 5 miles, it then crosses the ridge of Serapheum, about 8 miles in width, with a maximum cut of 61 feet. After this, proceeding southwards, the line strikes the immense basin of the Bitter Lakes, where the level is, in many places, as great as will be required, and where comparatively little work will have to be done for twenty-three miles. This depression is bounded on the south by the ridge of Chalouf, about 5 miles wide, where there must be a cutting 55 feet deep, for a short distance. Between Chalouf and the Red Sea is the Plain of Suez, 10 miles in extent, as crossed by the canal, and elevated only a few feet above the sea level.

The construction of the harbor, or entrance to the canal, at the Suez end, presents no engineering obstacle of any account; the head of the Red sea is so completely land-locked, as never to be troubled with a very heavy swell; there is no current at all; so that it will only be necessary to dredge out a channel into deep water.

At Port Said, the northern terminus, there will be more trouble; nothing, however, which skill and money will not overcome. The harbor here, will be formed by two jetties or piers; the western one extending into the sea for a distance of 3850 yards; say 2¼ miles. Its direction being north-north-east, with the extreme end curving a little more to the east. The other pier will extend 2750 yards or a little more than 1½ miles, in a direction nearly north; its base or starting point is 1550 yards eastward from the base of the other, or western jetty; and its extremity will be 440 yards distant from the line of the other; thus giving a clear passage a quarter of a mile wide, into the harbor; which will be the easiest and safest entrance of any of the ports along the eastern shore of the Mediterranean. This triangular area of 575 acres will be dredged to a depth of 30 feet; forming an outer harbor, where vessels can anchor before entering the basins, which communicate with the canal.

These piers were commenced with stone, from the quarries at Mex, a few miles south-west from Alexandria, carried to Port Said in Greek sailing-vessels; but the cost was so great and the progress so slow, that some other mode had to be adopted. The work is now being continued under a contract with Messrs. Dussaud, Freres, who have recently built the harbors at Cherbourg and Marseilles, gentlemen of great experience in hydraulic engineering. The material used in place of stone is a concrete, formed of hydraulic lime, from Theil, France, and the sand which is dredged out of the harbor. The proportions of the mixture are 325 kilogrammes of lime, to one cubic metre of sand; say, 715 pounds to 37 cubic feet. The concrete is formed into large blocks, which measure 11 feet 3 inches in length; 6 feet 7 inches in width, by 5 feet in depth; looking like immense bricks; containing 370 cubic feet each (ten cubic metres) and weighing 22 tons. As we saw them manufactured, the lime and sand were ground together, in large, circular, cast-iron troughs, about 12 feet in diameter; in each trough there ran 3 heavy iron wheels, which completely pulverized the lime, and thoroughly mixed the ingredients. The grinding was continued for about 20 minutes; a small quantity of sea-water being added from time

to time, until the mass had assumed the consistency of a thick mortar. A trap-door in the bottom of the trough was then opened, and the mortar fell into a car, standing below. A line of rails guided the car to where the moulds were set up, and into these the mortar is dumped, and carefully rammed into the corners. In about a week's time the concrete has so "set," or dried, as to retain its shape, after the planks and clamps which form the mould, are removed; these are then set up again in another part of the yard. After drying in the open air for about three months, these blocks become hard enough to bear handling without danger of being broken; they are then raised by a steam crane and placed on a car, on which they are conveyed to the dock. Here another crane lifts them from the car, and places them on the deck of a barge, fitted to receive three of the blocks at a time; they rest upon a platform which has an inclination of about 20°, and are retained in their position by iron "fingers," attached to an iron bar, which runs across the lower ends of the three masses. The barge is then towed to the proper position, in the line of the proposed pier, as marked by signal-flags, on shore, and by buoys. When in line, the "fingers" are made to release their hold upon the blocks, and they slide off the barge into the water. After having been submerged for a few months, the concrete becomes nearly as hard as granite. When the accumulation of blocks has approached so near to the surface of the water as to prevent the passage of the barge across the line of the pier, the blocks are lifted from the barge by a floating crane, and deposited in their destined positions, one above another, until the top of the pier is about 15 feet above the surface. There are about 30 of these blocks made per day, and the same number daily submerged. The price paid to the contractors is 400 francs each;* there will be required about 30,000 of them; making the cost of the two piers, twelve million francs. About 10,000 blocks had been sunk up to March, 1867.

There is a very decided current from the west setting along this coast, which brings with it a considerable quantity of sand; this sand fills up the spaces and interstices between the blocks in the piers, thus forming a solid mass, which promises to stand for all time.

It was stipulated by the terms of the detailed concession of January, 1856, from Mohammed Said to Mons. de Lesseps, that four-fifths of the laborers to be employed in digging the canal, should

* About $5·50 per cubic yard.

be *Fellahs*, or native Egyptians, who were to be furnished by the viceroy in such numbers as might be required by the engineers of the company. They were to be paid by the company at the rate of 12½ to 15 cents per day, (2½ to 3 piastres,) for all laborers over twelve years of age; those under twelve were to receive 5 cents, or one piastre per day, as wages; but a ration for their subsistence to the value of one piastre per day, additional, was to be given to each one irrespective of age. The number of persons thus employed was usually between twenty and thirty thousand; and the principal work on the canal was prosecuted under this agreement from 1859 to 1863. But it was found to be very unsatisfactory in its operation by each of the principal parties. The company could not get the men as they were wanted; they were not easily managed when obtained; and feeling no interest in the general enterprise, they did as little work as possible It was found that eighteen thousand of these laborers, working for ten months, had moved only four million cubic metres of earth; being less than one cubic metre per man per day;* whereas the engineers had calculated that a metre and a quarter would be an easy day's work.† It was found too, that the withdrawal of so many hands from the agricultural force of Egypt was causing a general derangement of its internal affairs; and greatly diminished the amount of taxes received. Still another trouble was, that through the representations of the English ambassador at Constantinople, the sultan was induced to look upon this forced labor of the *Fellahs*, as a form of slavery; and he refused to confirm the concessions of the viceroy, so long as this state of affairs continued. Matters lingered along in this most unsatisfactory condition for two or three years; until in May, 1864, the *Fellahs* were wholly withdrawn from the work. Another article in the concession of Mohammed Said to the company, gave them the right to dig the fresh water canal from Ismailia to Suez, which has been before alluded to. This line was wholly in the desert, a distance of nearly 60 miles through a barren, desolate country, entirely worthless as it then was. The company were also to be allowed to own in fee simple, as much of this waste land as they could reclaim and render fit for cultivation, by means of the water, for irrigation, from the canal which they were to dig. These lands were to be exempt from all taxation for ten years, and

* 1⅓ cubic yards.

† About six times this quantity is a fair day's work in this country.

after that time, were to pay the same revenue or tax to the Egyptian government, as was imposed on similar lands elsewhere. The company were also permitted to use the fresh-water canal for purposes of transportation, and to receive toll for boats and merchandise passing through it.

It was soon discovered that *water* was all that was needed, to make these sandy wastes really valuable; and the terms for their lease, which the company were prepared to offer, were so liberal, as would speedily induce a large number of French agriculturalists to settle upon them. This caused more trouble and delay at Constantinople; as the English were afraid to have a numerous French colony on the Isthmus of Suez, lest their communication with India should be endangered thereby. The sultan was induced to view the matter in this light, and to withhold his assent from such an arrangement. These difficulties caused a general stagnation in the affairs of the canal company; and for two years their work was almost entirely suspended. The whole subject of the concessions from the viceroy to the company was at last submitted to the arbitration of the Emperor Napoleon, who, in July, 1864, rendered a decision to this effect: 1st. That the concessions of November, 1854, and January, 1856, had the form of a contract, and were binding on the two parties. 2d. That by reason of the withdrawal of the *Fellahs* as laborers, the cost of the work on the canal would be increased; and that the viceroy should pay on that account, an indemnity of thirty-eight million francs to the company. 3d. That the company should cede to the viceroy all of their fresh-water canals; reserving only the right of passage through them. And that the viceroy should pay ten million francs for the canals, as representing their cost of construction, and six million francs additional, as compensation for the tolls, which the company thereby relinquished. 4th. That the company should retain only such lands along the line of the ship canal, as might be necessary for the proper working and care of it, as a line of passage between the two seas. 5th. That the company should re-cede to the viceroy, their right and title to all lands susceptible of cultivation by means of irrigation from the fresh-water canals; and that the viceroy should pay therefor thirty million francs. This area being estimated at sixty thousand hectares, valued at five hundred francs per hectare; say, forty dollars per acre, for the naked desert. This made a sum total of eighty-four million francs, to be paid as decreed by the

Emperor. The company also agreed to sell to the viceroy, for ten million francs, the "Ouady" property, which they had purchased from El Hamy Pasha. These items, together with the balances due on the company's shares, subscribed for by the viceroy, made a sum total of one hundred and eleven million francs. From this amount there was deducted about nine million francs, as money already paid; leaving a net balance of about one hundred and two million francs still due. Of this, the viceroy paid about twenty-three and a quarter million francs, in 1866; and is now paying at the rate of three million francs per month for this year, 1867. The balance is to be paid at the rate of about one million and a half francs per month, during 1868 and 1869. It is mainly with this money, that the work on the canal is being prosecuted; the required balance being furnished by the share-holders. The total and sudden loss of the *Fellahs*, as laborers, had the effect of retarding the completion of the canal; it being necessary to substitute therefor, steam machinery, and to organize an entirely new system for continuing the work. In this respect there has been the most gratifying success. The principal contract for the excavations along the whole line of the canal, has been awarded to Messrs. Borel and Lavalley, at the price of one hundred and twenty million francs; based upon the estimate of fifty-one million cubic metres of earth to be moved, at two francs, twenty centimes per metre. They agree to have the entire work finished by December, 1869; being stimulated by a large bonus, if completed before that date, and incurring a heavy penalty for each month of delay beyond the time specified. In this immense undertaking, Mons. Borel is the financial manager; and to Mons. Lavalley is entrusted the engineering and executive department. He is a graduate of the "Ecole Polytechnique," and had already shown himself to be one of the first mechanical engineers in Europe, before undertaking this great enterprize. The machines now in use along the line have either been invented by him, as occasion required, or have been especially adapted to do the work in hand. The principal instrument employed, is a large dredging machine, with iron buckets, which are fastened to an endless chain, revolving over two drums; one at the end of a long movable arm, to regulate the depth at which the buckets or scoops shall come in contact with the earth to be excavated, and the other at the top of a heavy frame-work of iron, standing in the centre of the body or hull of the machine. The size of these dredges varies

according to the work to be done, and especially as regards the disposition to be made of the excavated material. Those first in use were of very much less capacity than the new ones of later construction. The body or hull of the smaller size is about 83 feet long by 23 feet broad; with the axis of the upper drum 28 feet above the surface of the water. These have engines of 15-horse power, and are capable of excavating about 300 cubic yards of sand per day. The size of the newer dredges was increased from time to time as was deemed prudent, and was warranted by the success of those which had preceded them; the second class having an elevation of 38 feet for their axis, while those of the third class have their drums 48 feet above the water, with their hulls 110 feet long, by 27 feet broad; the material of the hulls in all cases is boiler iron, and in shape they are rectangular. The capacity of these largest machines is equal to 2500 cubic yards per day, of 12 hours, when working without interruption; their engines are of seventy-five horse power. The "prize dredging" for the month preceding my visit, was an average of 1,700 cubic metres per day. The sand when elevated by these dredges is disposed of in one of three ways, according to the position in which the machine is at work. If the earth is required for filling, or is wanted for making of the concrete blocks, it is then emptied into large boxes, holding about 4 cubic yards each; seven of these boxes fit into a barge of peculiar construction, and they are filled by being brought under the spout of the dredge. The barge is then floated to the desired point, where the boxes are lifted from it by a steam-crane and placed upon cars, which run on tram-ways in such directions as may be required. One end of the box opens on hinges, so that the contents may be dumped quite easily.

(To be continued.)

THE U. S. STEAMSHIP "WAMPANOAG."

DURING the late war of the Rebellion, it became the declared policy of our Government, to provide a reliable system of coast-defence, and to rely, for aggression, upon a fleet of vessels of exceptionally high speed, and of comparatively light armament, that should prey upon the commerce of the enemy, while being capable of readily avoiding a conflict with the heavily-armed cruisers of the foe.

The *Wampanoag*, one of these American *Alabamas*, has recently

made a trial at full speed, and her success may be judged by the report given below.

The greatest speed attained by any foreign naval-steamer is about fourteen and a half knots at the measured mile. From that speed about twenty *per cent.* must be deducted for their speed at sea, say the English authorities. The speed of the *Wampanoag* fleet is therefore several knots higher than that of any naval vessels afloat.

Her "coefficient of performance" is also remarkably high, and she is said to be exceedingly economical in consumption of coal.

Says the British "*Army and Navy Gazette*," of March 13th, "We may well ask, what would *we* not give to have a class of vessels with such a heavy armament, and anything like the speed?"

REPORT OF THE BOARD OF ENGINEERS.

UNITED STATES STEAMER WAMPANOAG,
Hampton Roads, Virginia, February 17, 1868.

SIR: We have the honor to report, that we have completed the trial of the machinery of the *Wampanoag* at sea, with the vessel driven at the maximum speed, under steam alone, during 37½ consecutive hours; and at the speed of 11 nautical miles per hour, under steam alone, during 25 consecutive hours; the latter performance being to ascertain with what consumption of coal per hour the speed of 11 knots can be maintained at sea.

The average performance during the 37½ consecutive hours of maximum speed was as follows:

Average speed of vessel per hour in nautical miles	16·71
Average speed of vessel per hour in statute miles	19·265
Average number of the revolutions of the engines per minute	31·06
Average number of the revolutions of the screw per minute	63·673
Average steam pressure in boilers in pounds per square inch	31·97
Average position of the throttle valves open	wide.
Average consumption of coal in pounds per hour	12·690

There was a fresh breeze abaft the beam, with a moderate sea most of the time on the quarter; the latter part of the trial the sea was heavy. During the above maximum performance the vessel averaged, for 24 consecutive hours, 16·97 nautical miles, or 19·566 statute miles, per hour. During 12 consecutive hours, 16·98 nautical miles, or 19·577 statute miles, per hour; and during 6 consecutive hours, 17·25 nautical miles, or 19·89 statute miles, per hour.

The greatest distance run in any one hour was 17·75 nautical miles, or 20·465 statute miles; the latter speed was obtained and logged four separate half hours, and it is only necessary that the

men shall be properly drilled at their duties in the fire-room and coal-bunkers to maintain that speed continuously in smooth water.

The average performance during the 25 consecutive hours, with the intended speed of 11 nautical miles per hour, was as follows:

Average speed of the vessel in nautical miles per hour	11·39
Average speed of the vessel in statute miles per hour	13·13
Average number of revolutions of the engine per minute	21·36
Average number of revolutions of the screw per minute	43·78
Average steam pressure in the boilers in pounds per square inch	20·69
Average position of the throttle valves open	$\frac{8}{10}$ of 1 hole.
Average consumption of coal per hour in pounds	3·474

There was a light wind and sea ahead for six hours, and a light breeze and moderate sea abaft the beam during nineteen hours of the trial, when it was suddenly interrupted by a gale.

The main valves, gearing, and all other parts of the machinery worked smoothly and in a satisfactory manner, and every journal of the engines, during their entire performance at sea since leaving the navy yard on the 4th instant, worked perfectly cool until the 38th hour of the maximum speed trial, when the crank-pin of the after engine began to warm; the speed of the engines was then reduced by throttling, the first had only time for any requirements of the machinery. The warming of the crank-pin did no injury whatever, nor would it have been the cause of a non-completion of the 48 hours' trial at maximum speed. There was no foaming or priming in the boilers, and the performance of the whole machinery was excellent, and it returned to this port in a condition for any service without requiring repairs.

The maximum performance can be easily maintained during a passage across the Atlantic, or for any required service, and we are of opinion that it is not equalled for speed or economy by that of any sea-going screw vessel of either the merchant or naval service of any country.

Very respectfully, your obedient servants,

THEO. ZELLER,
Chief Engineer U. S. N.
JNO. S. ALBERT,
Chief Engineer U. S. N.
JOHN H. LONG,
Chief Engineer U. S. N.

Hon. GIDEON WELLES,
Secretary of the Navy, Washington, D. C.

Mechanics, Physics and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 257.)

§ V. *The General Properties of Matter.—The Constitution of Matter according to the Molecular Hypothesis.*

Matter is that which affects our senses. (See § 1).

A body is a portion of matter limited in all directions.

In the different manners in which bodies affect our senses, consist the properties of bodies. These properties are either *general*, that is, belonging to all bodies, whether solid, liquid or gaseous, and therefore come under the head of physics, or they are *special*, and therefore belong to the province of chemistry. (See definitions of Physics and Chemistry, in § 1).

Matter possesses several general properties, of which two are called *essential* properties; for without them we cannot conceive of the existence of matter, and therefore they can serve to define it. These two properties are *extension* and impenetrability.

The following is a list of the general properties of bodies:—

1. Extension.	Necessary to our perception of matter.
2. Impenetrability.	
3. Figure.	
4. Divisibility.	
5. Compressibility.	
6. Dilatability.	
7. Porosity.	
8. Mobility.	Ultimate properties according to the molecular hypothesis.
9. Inertia.	
10. Attraction and	
11. Repulsion.	
12. Polarity.	
13. Elasticity.	

1. *Extension.*

Extension is the property which every body possesses of occupying a portion of space, which we call its volume. A body always presents the three dimensions—length, breadth, and thickness; and it is by abstraction only that in geometry we consider *surfaces*, which are the boundaries of bodies, and have only length and breadth; and *lines*, which are the boundaries of surfaces, and have only length; and *points*, which are the terminations of lines, and have alone position.

For the measurements of extension, see § II.

2. *Impenetrability.*

The property which every body has of excluding every other body from the space which it occupies.

In ordinary language, we say that one body is penetrated by another, but in all these cases it is found that the particles of the one body are merely *displaced* by the other.

Examples. A needle *penetrating* (displacing) mercury contained in a fine glass tube. The mercury rises in the tube, as the needle descends, to an amount exactly equal to what would be produced by pouring into the tube a quantity of mercury equal to the volume of that portion of the needle below the surface of the mercury.

A liquid cannot be poured into a vessel unless the air, which it contains, goes out as it enters.

Consider the images formed in the foci of converging lenses and mirrors; and also a shadow.

We can now define matter as *all that* which has both extension and impenetrability, and therefore void space or *vacuum* is space without impenetrability,—being penetrable.

3. *Figure.*

The bounding surfaces of a body give it its figure or form.

That department of science which discusses and classifies the forms of nature, is called Morphology.

The forms of bodies may be arranged under two divisions.

I. *Regular Forms.* II. *Irregular or Amorphous Forms.*

Regular forms can be embraced in two classes (*a* and *b*).

a. Forms of matter produced by the action of forces not directed by the vital principle.

1. Forms of the heavenly bodies. Considered in Astronomy.

Forms of liquids in motion; as "the liquid vein;" (see researches of Poncelet, Savart and Magnus), the rain drop; the forms of waves.

Forms of liquid at rest; (not contained in vessels) as the dew-drop; the soap-bubble.

Forms of liquids not subject to the action of gravity; as the forms assumed by oil—suspended in a mixture of water and alcohol of the same density as itself—when subjected to various conditions of molecular action. (See Plateau's *experimental and theoretical researches on the figures of equilibrium of a liquid mass withdrawn from the action of gravity.* Translated in Smithsonian Reports, 1863, *et seq.*

2. Forms of crystals. The laws ruling these forms considered in the science of Crystallography.

b. Forms of matter produced by the action of forces directed by the vital principle.

1. Forms of plants. Considered in botany.

2. Forms of animals. Considered in zoölogy.

All the forms of matter not contained in the foregoing classes are irregular or *amorphous*, and belong to class II.

Diagrams illustrating above classification of forms.

4. *Divisibility.*

Every body can be divided into many parts, and these parts can be further subdivided until the parts become so minute as to escape observation, even when aided by the most powerful microscopes.

That matter was susceptible of very minute division, was known to the philosophers of ancient Greece and of India, and they discussed the question, whether matter was infinitely divisible, or divisible only to a certain minuteness, when the parts were supposed to be unalterable by any means, whether mechanical or chemical. Mathematically speaking, the division has no limit, for however small the residual particles may be, nevertheless, since they have extension they have divisibility. But we demand not what may be conceived, but what really exists; and in fact, the discussions of the ancients are about the infinite divisibility of space, and prove nothing as to the actual divisibility of matter.

Anaxagoras and Aristotle admitted its infinite divisibility; Leucippus maintained a contrary opinion, and Democritus, siding with Leucippus, gave the name of *atoms* to the ultimate unalterable parts of which he supposed all bodies to be composed. Epicurus attempted

to develope the ideas of Democritus, that found in the seventeenth century a zealous defender in Gassendi, whilst Descartes upheld the opinion of Aristotle.

But we have in the phenomena of molecular physics, in the laws of combination in chemistry, and in the facts of crystallography strong evidence that all bodies are composed of ultimate excessively small parts, which are invisible, even with the aid of the most powerful microscopes, but still of finite dimensions, of infinite hardness, unalterable by any means, and separated from each other by spaces which are very great when compared with their size. These parts which are the limits of the possible division of matter, are called *atoms* (Gr. ἄτομος; ἀ privative and τέμνω, to cut.)

According to this hypothesis, a union or grouping of two or more atoms forms a *molecule;* a combination of molecules a *compound molecule*, and a union of the latter a particle.

The sensible division of matter can be carried to a very minute limit.

Examples. Gold can be beaten into leaves $\frac{1}{282000}$th of a millimètre thick.

Silver wire, gilded with $\frac{1}{360}$th of its diameter of gold, can be drawn so fine that one mètre weighs only eight milligrammes. The gold film on this wire is now only $\frac{1}{800000}$th of a millimètre thick. By placing a short piece of this wire in nitric acid, the silver core is dissolved out, leaving a tube of gold, having a wall only the $\frac{1}{800000}$th millimètre thick. Now, under the best microscopes, we can discern a surface of $\frac{1}{40000}$th of a millimètre in diameter; therefore we can divide gold into particles $\frac{1}{40000}$th millimètre in diameter, and $\frac{1}{800000}$th millimètre thick; yet each of these parts has all the physical and chemical properties of a large mass, as can be determined by testing it under a microscope.

Dr. Wollaston drew platinum wire so fine that its diameter was only $\frac{1}{12000}$th millimètre ($\frac{1}{300000}$th inch); and although platinum is the heaviest of the metals, yet it took 200 mètres of this wire to equal one centigramme in weight; or, in other words, one mile of this wire weighed about one grain. Dr. Wollaston accomplished this by wire-drawing a cylinder of silver $\frac{1}{5}$th of an inch in diameter, having in its axis a platinum wire $\frac{1}{100}$th inch diameter, and after having obtained a very fine wire—having in its interior a platinum wire of still greater tenuity—he dissolved with nitric acid the silver coating, and thus obtained an almost invisible platinum wire.

The thickness of a soap-bubble, in the dark spot which is formed on it just before it bursts, is $\frac{1}{100000}$th millimètre.

Divisibility of matter in solution. One grain of carmine tinges ten pounds of water, which we can divide into about 617,000 drops. If we suppose that 100 particles of carmine are requisite to produce a uniform tint in each drop, it follows that the one grain of carmine has been divided into 62,000,000 parts.

Metallic solutions and chemical tests.

Illustrations from organized bodies.

The thread of a spider is composed of more than 1000 separate threads.

The diameter of the red disks contained in human blood is $\frac{1}{4000}$th inch; while the diameter of the blood-disks of the Java musk-deer is only the $\frac{1}{12325}$ inch, so that a drop of this deer's blood, such as would adhere to the point of a fine needle, would contain 150,000,000 disks.

It has been calculated that some of the siliceous plates which cover and give rigidity to the minute vegetable cell-plants, called diatomaceæ, weigh only $\frac{1}{2000000000}$th of a grain; yet the surfaces of these plates are covered with the most exquisite tracery of siliceous stria or bars, often not more than $\frac{1}{85000}$th inch in width and thickness. Now we can discern a surface of $\frac{1}{85000}$th inch in the best microscopes, and a portion of one of these siliceous disks of that area would weigh only about $\frac{1}{18000000000000}$th of a grain.

Divisibility of odorous substances.

A portion of musk will give off a powerful odor during a year, and yet its diminution in weight has not been sufficient to be detected by the most delicate balance.

"In order to offer an inexact idea of the minuteness of the particles of musk which are still capable of imparting some odor, we state, after a well known experimenting physiologist, that a certain liquid, containing as much of an extract of spirit of musk as $\frac{1}{20000000000}$th part of its whole weight, was at this time still distinctly odorous. A grain's weight of a liquid of which $\frac{1}{2000000}$th part was of that extract, spread an intensely penetrating odor. Next after musk are to be mentioned certain flower ethers, especially the oil of roses, a little drop of which is sufficient to fill with odor an immense atmosphere. The same physiologist states that a certain space filled with air, of which, at the highest, only $\frac{1}{100000000}$th part was vapor of oil of roses, still diffused a distinct odor of roses." See article "On the Senses," in Smithsonian Report, 1865.

5. *Compressibility.*

All bodies when subjected to exterior pressure are reduced in volume, and since all bodies can thus be indefinitely compressed, it follows that the matter of which bodies are composed does not fill the space which is contained within their bounding surfaces; or, as it is sometimes stated, a body does not form a *plenum* of matter.

The compressibility of solids is seen in all structures and machines where matter experiences great pressure; *e. g.* The stone pillars which support the dome of the Pantheon, at Paris, sensibly diminished in height as the weight which they bear was placed upon them, and a visible depression takes places in the arches of massive bridges when the "centres" are knocked away.

The relief of coins and medals is produced by subjecting disks of metal, placed between hard steel dies, to an intense and sudden pressure, which is so great that the metal disk is not only changed in form, but its *volume* after being struck is appreciably less than before.

For a long time, liquids were regarded as incompressible, and this opinion seemed to be confirmed by many experiments which the Academy of Florence made during the end of the seventeenth century. Their most celebrated experiment, which, however, had previously been made by Lord Bacon, consisted in filling a hollow silver sphere with water, and after stopping the orifice with a screw-plug, subjecting it to the powerful pressure of a screw-press. It is evident that if the sphere is flattened, its capacity is diminished, and the water compressed. They were surprised, however, to see the water appear on the exterior surface, as a fine dew, and they thence concluded that water was incompressible, and silver porous to this liquid.

John Canton, in Trans. R. S. 1762, first showed that liquids were compressible, even with the pressure of one atmosphere. His apparatus consisted of a large thermometer which contained the liquid, and the bulb of which was inclosed in an exhausted receiver. The liquid was thus entirely relieved of atmospheric pressure. The height of the liquid was now marked upon the stem, and the end of the sealed thermometer tube being broken, the air was allowed to enter the stem and press upon the surface of the liquid, and to enter the receiver and press upon the outside of the bulb. The liquid instantly fell in the tube, thus clearly showing a compression produced by the pressure of one atmosphere.

Canton thus found that water was compressed $\frac{46}{1000000}$ths of its volume by the pressure ef one atmosphere, and this determination is quite exact.

In 1826, Jacob Perkins described in the Trans. R. S. an appparatus which renders the compressibility of liquids very evident. Into a hollow cylinder passed a rod through a stuffing-box, and around this rod tightly fitted a leather washer, which rested on the top of the cylinder. This apparatus being filled with water, or other liquid, was placed in a closed cannon, into which water was forced by a strong pump, until a certain pressure was attained, which was measured by the lifting of a safety-valve and the escape of water.

On taking out the cylinder from the cannon, the leather washer was found on the rod several inches above the place it occupied before the experiment, thus showing that the rod had entered by that quantity into the vessel, as the pressure which it exerted compressed the liquid.

Describe and use Œrsted's piezometer, and exhibit table of Regnault and Grassi's results on the compressibility of liquids.

Gases, of all bodies, are the most easily compressed. This fact is readily shown by enclosing a gas in a cylinder, into which glides an air-tight piston. By pressing on the piston, it is forced into the cylinder, and the gas is reduced in volume. On relieving it of pressure, the gas expands to the volume it had before the experiment, and will do so no matter into how small a volume it may have been compressed, or how often the experiment may have been made. In this respect (of perfect elasticity) gases and liquids differ from solids. This is explained by the fact, that the ultimate parts of solids have *polarity*.

It is found that by pressure, gases are reduced to volumes, which are the reciprocals of the pressures.

6. *Dilatability.*

When any body is subjected to exterior pressure on all its surfaces, it is forced into a smaller volume, but on the pressure being removed, it expands to the dimension it had before the pressure was applied. Also, the volumes of all bodies are increased by a rise in their temperature: and Cagnard—Latour has shown that wires and rods when stretched, have their volumes increased.

This general property of increase in volume from these causes is called dilatability.

The dilation of solids and of liquids is shown by their expansion, when relieved of hydrostatic and atmospheric pressures: and any gas expands when the atmospheric pressure is removed.

Experiments. The expansion of solids shown when relieved of powerful pressure. The experiment of Canton *reversed*, shows the expansion of a liquid as the pressure of the atmosphere is removed.

The expansion by heat, shown by Saxton's pyrometer, of liquids and of gases by large liquid and air thermometers.

Experiments of stretching wires and India-rubber, with Cagnard —Latour's apparatus.

(To be continued.)

PATENTING A PRINCIPLE.*

THE opinions of professional men are far from being settled, apparently, upon all the questions involved in patenting a principle. Perhaps there are not many who suppose that having discovered such a principle entitles the discoverer to appropriate it under a patent, provided he has reduced it to practice. The current of decisions has been so uniform in recognizing the title as belonging to the one who has first made a useful application of a law of nature, and upon that ground alone, that a person can hardly be found who believes the title to be strengthened in consequence of having brought the law to light. A much greater diversity of sentiment exists as to the extent of the right which the individual acquires in the principle so applied, and the form in which a patent should be expressed in order to protect the right. On the one hand, it seems to be held that he is entitled to the exclusive use of the principle, when employed for the same purpose by whatever instrumentalities the purpose is effected; and that the patent should expressly claim, not only the instrumentalities adopted by the patentee, but also the use of the principle for the purpose however applied. Others believe that, having shown by what means the principle can be made to

* The above article is from the pen of S. H. Hodges, Esq., senior member of the Board of Appeal, in the United States Patent Office, and was officially "commended to the Examiners of the Patent Office for their perusal and study," by the late Commissioner of Patents. It is well worthy of careful examination as containing a full digest of the law in the interesting question of which it treats.—ED.

accomplish the object, the patent, although it covers only those means in express terms, yet confers an exclusive privilege in the employment of the principle to accomplish the object, let the means resorted to be ever so different. On the other hand, it is regarded by many as well settled, that he who has invented a method by which a property of matter can be, for the first time, rendered useful for a particular purpose, is entitled to a patent for the method, or process or mechanism which he has contrived, and that he can set up no claim to anything more, nor vindicate a right to anything more.

Several things have contributed to this discordance of sentiment. One of the most prominent is a misapprehension of the effect and bearing of some of the cases on the subject. It is not necessary to engage in an exhaustive discussion of all the reported decisions in which the question is involved; but some examination of a few of the leading ones seems to be requisite in order to render it clear.

From the earliest date, the established doctrine of the English courts has been that a principle cannot be patented. It has been pronounced from the bench times without number, has been uniformly assumed as the law, and has never once been questioned since Hornblower *v.* Boulton was determined. It appears to have been made the subject of consideration for the first time in two suits brought upon Watt's patent for his steam-engine. In one of them, Boulton & Watt *v.* Bull, 2 H. B. 463, and Dav. Pat. Cas. 162, the court were divided in their construction of the patent, and consequently no judgment was ever rendered. All were agreed in condemning the idea that a principle could be patented, and two of the judges interpreted the grant as embracing a monopoly of a principle, and held it to be void on that ground. The other two understood it to cover only the structure of the engine, and therefore maintained its validity. Lord Chief Justice EYRE uttered the following noticeable sentiments on the occasion: "Undoubtedly there can be no patent for a mere principle. But for a principle so far embodied and connected with corporal substances, as to be in a condition to act, and to produce effects in any art, trade, mystery, or manual occupation, I think there may be a patent. Now this is, in my judgment, the thing for which the patent was granted; and this is what the specification describes, though it miscalls it a principle. It is not that the patentee conceived an abstract notion that the consumption of steam in fire-engines may be lessened, but he has dis-

covered a practical method of doing it; and for that practical method of doing it he has taken out a patent. Surely this is a very different thing from taking out a patent for a principle." The expression "a principle embodied and connected with corporal substances," &c., may have had some part in originating the idea that the principle itself is what may be patented. It may be doubted whether the distinction between a principle embodied in a material structure, and a machine embodying a principle, was in his lordship's mind at all. If it was, the latter part of the quotation shows that it was the machine he contemplated: he says it was "for that practical method of doing it he has taken out his patent."

Having failed to establish their title in that suit, the plaintiffs brought another, which was subsequently carried by writ of error to the Court of King's Bench, and is reported by the name of Hornblower *v.* Boulton, 8 T. R. 99. Judgment was given in their favor upon the sole ground that the patent was for a machine, and not for a principle, as may be seen from the following language of Lord KENYON, Chief Justice: "By comparing the patent and the manufacture together, it evidently appears that the patentee claims a monopoly for an engine, or a machine composed of material parts, which are to produce the effect described." "But having heard everything that can be said on the subject, I have no doubt in saying that this is a patent for a manufacture, which I understand to be something made by the hand of man." LAWRENCE, J., rested the same conclusion upon the language of the Act of Parliament, under which the patent had been extended; saying, "From this it is clear that the legislature understood that the patent was for an engine for some mechanical contrivance." The other judges concurred in these views, and, notwithstanding the strenuous efforts of the counsel to sustain the patent upon the ground that a principle could be patented, they emphatically condemned the position.

Passing over several cases, which will be adverted to in the following pages, the case of Neilson *v.* Harford, 1 W. P. C. 273, and 8 M. & W. 806, next demands attention. The action was brought upon the patent for using the hot-blast in smelting iron, and the like, and was considered at great length in the Court of Exchequer Chamber. The court were chiefly occupied with the objection, that the patent represented the form of the vessel in which the air is heated to be immaterial, and this the jury had found was not true, certainly in one sense. It was also urged that the patent was for a

principle; and respecting this, Baron PARKE, who pronounced the opinion, made these observations: "Then taking the construction of this specification upon ourselves, as we are bound to do, it becomes necessary to examine what the nature of the invention is which the plaintiff has disclosed by this instrument. *It is very difficult to distinguish it from a patent for a principle, and this at first created in the minds of some of the court much difficulty;* but after full consideration, we think the plaintiff does not merely claim a principle, but a machine embodying a principle, and a very valuable one. *We think the case must be considered as if, the principle being well known, the plaintiff had first invented a mode of applying it* by a mechanical apparatus to a furnace. And his invention then consists in this, by interposing a receptacle for heated air between the blowing apparatus and the furnace" (W. P. C. 370, 371). It is difficult to see how they could have more emphatically denied that a principle can be patented. The inventor had brought to light a property of matter of immense value, and had rendered it practicable. If there was ever a case in which such a discovery should be protected it was this, and the court were evidently actuated by an earnest desire to secure to the discoverer his reward. Yet they found themselves compelled to put a forced interpretation upon his grant, and to construe it as covering the structure he employed, because they could not, with due regard to their legal convictions, allow him to monopolize the property of matter. They add this pregnant remark: "We think the case must be considered as if, the principle being well known, the plaintiff had first invented a mode of applying it." They give him no credit for having been the first to eliminate it, and make it known. They estimate his merit by the application which he had made of it, and by that alone.

The same patent came under consideration soon after in The Household Co. *v.* Neilson, W. P. C. 673, a case which requires a more careful examination, perhaps, than any other on the subject both on account of the erroneous significance which has been attached to it, and the influence it has exerted in misleading many of the profession. It was tried first by the Court of Sessions in Scotland, Lord Justice Clerk HOPE presiding, and then on appeal by the House of Lords. The defendants undertook to raise questions which involved the objection that the patent was for an abstract principle, and therefore void. Lord HOPE thereupon (p. 677) expressed his conviction that they were not at liberty under the pleadings, or

issues as settled, to go into that defence. On inspecting the issues (p. 674), it will be clearly seen that no such point was raised. Nevertheless, in order to enable the defendants to carry up the question, he concluded to entertain the objection, and treat it as if it were legitimately before him. Accordingly, he proceeded to instruct the jury in unqualified terms, that the plaintiff, having discovered the principle, and shown how it might be applied usefully, was entitled to a patent for the principle. All this, however, was on the erroneous hypothesis that the objection had been properly taken.

It has been said, however, that this ruling of Lord HOPE's was affirmed upon the hearing of the appeal before the House of Lords. It is true that all the exceptions taken by the defendants to his lordship's instructions were overruled on that occasion, saving one, which has no bearing on the question under consideration. The reason is to be learned from a foot note to the report, on p. 711. From that it appears that, when the counsel for the appellants (the defendants below), approached this part of the case, the law lords expressed such a decided conviction that the objection to the patent on account of its being for a principle, could not be raised under the pleadings and issues, that the objection was abandoned. And in accordance with this we find Lord CAMPBELL interposing in the course of the argument, and asking the counsel for the appellants "what issue have you on this record to raise the question of the patent being for a principle?" And after some further conversation he told them "You might have pleaded that it was a patent for a principle, and not for any particular mode of applying a principle. There is no issue for the direction of the judge upon that point:" pp. 701, 702. And Lord LYNDHURST mentioned, in delivering his opinion, that he understood the counsel to abandon that defence (p. 711). The decision below was affirmed, nevertheless, because, since the defendants could not raise the question at all, they were not injured by an adverse ruling respecting it, and could not allege it as an error, so as to set aside the judgment. The whole authority of the case, therefore, rests upon the instructions given by Lord HOPE to the jury, hypothetically and upon a supposition that had no foundation, as he himself believed.

Among the American cases on this subject two are prominent: those of Le Roy *v.* Tatham, 14 How. 156; and O'Reilly *v.* Morse, 15 How. 62.

In the first of these the patentees described in their specification

a property of lead, which had been discovered by them, viz: that, if divided when just congealed, and then pressed together while still hot, the edges will unite. This they had reduced to practice in a machine for making lead pipe, and it was found to be a valuable improvement. Judge McLEAN, who gave the opinion of the majority of the court, interpreted the patent as embracing the machine only, and as they determined that to have been anticipated, they condemned the patent.

(To be continued.)

FLAME REACTIONS.

By Prof. Bunsen.

Translated by Prof. Charles F. Himes, Ph. D., Dickinson College, Carlisle, Pa.

(Continued from page 269.)

XXIV.—Behavior of Molybdenum Compounds.

A. *On a charcoal rod with soda*, molybdenum is reducible to a gray powder, but with such difficulty, that its detection in this way is unadvisable. Some molybdenum compounds likewise give, in the upper reducing flame, with great difficulty and incompletely, a metallic incrustation upon porcelain, and at the same time color the flame greenish. Molybdenum is recognized best in its compounds in the following way:

B. The test-specimen, finely pulverized by means of the steel blade, Fig. 4, A, upon the porcelain plate, Fig. 3, is mixed upon the hand with soda, which is obtained in the pasty condition best adapted to mixing, by fusing off a portion of a crystal of carbonate of soda. After the mixture has been fused for a few seconds in the lamp-flame, in a spiral of platinum wire of the thickness of a hair, from two to three millimetres wide, the white-hot fluid contents of the spiral are knocked off on to the lamp-plate, then digested with two to three drops of water by warming, and the clear liquid above the sediment is soaked up into three or four strips of filter-paper, not too fine, several millimetres broad.

B′. One of these strips when moistened with hydrochloric acid does not change its color, but if a drop of ferrocyanide of potassium is placed upon the moistened paper, it becomes reddish-brown.

B″. If one of the strips is gradually moistened with a few milligrammes of proto-chloride of tin, it either becomes blue, even in the cold, or upon gently warming it; if it becomes yellow or yellowish-brown, more of the solution of the test-specimen, treated with carbonate of soda, must be added by means of a capillary pipette, in order to cause the blue color to appear.

B‴. A drop of sulphide of ammonium placed upon the third strip produces a brown coloration, and upon the addition of hydrochloric acid a brown precipitate, whereupon the paper often becomes blue on the margin of the precipitate.

B⁗. The yellow phosphoric acid precipitate, which the solution in nitric acid of ammonia salts of molybdic acid gives, can be produced in a similar way.

C. The slightly characteristic borax bead is colorless in the oxidizing flame, when it contains more molybdenum bluish, enamel-like; in the reducing flame dark, by reason of separated binoxide of molybdenum.

XXV.—Behavior of Tungsten Compounds.

The reduction of tungsten on a charcoal rod, with soda, also succeeds, but is also not adapted to the separation or recognition of the metal. The compounds of tungsten are therefore treated in the manner just given for molybdenum, by soaking up the fluid, after fluxing with soda, on to strips of blotting paper.

A. One strip moistened with hydrochloric acid remains white, but becomes yellow upon heating; moistened with ferrocyanide of potassium, no coloration occurs.

A″. Another strip treated with drops of proto-chloride of tin becomes blue, even when cold, or upon warming.

A‴. A drop of sulphide of ammonium produces no precipitate upon a strip, neither alone nor after the addition of hydrochloric acid; the paper, however, is colored thereby blue or greenish, especially upon warming.

XXVI.—Behavior of Titanium Compounds.

These give, with microcosmic salt, in the oxidizing flame, a colorless bead, which acquires a slight amethyst color in the reducing flame. After the addition of some sulphate of iron, the bead acquires in the lower reducing flame the peculiar red color of venous blood, in the oxidizing flame the bright brown color of sesquioxide of iron can be reproduced as often as desired. The titanium

compounds are fluxed with carbonate of soda, with effervescence, to a bead, transparent during ignition, opaque upon cooling, which, when treated with proto-chloride of tin, whilst still hot, and exposed in the lower reducing flame, forms a gray mass, which dissolves in hydrochloric acid with weak amethyst color upon warming it upon the lamp-plate.

XXVII—XXVIII.—Behavior of Tantalum and Niobium Compounds.

These manifest the same reactions as those of titanium.

XXIX.—Behavior of Silica Compounds.

A. The silicates, when treated in the oxidizing flame with carbonate of soda, dissolve, more or less, with effervescence. The hot fused mass, when moistened with proto-chloride of tin and thoroughly ignited, does not give a trace of a blue coloration when evaporated upon the lamp-plate, whereby silica may be distinguished from titanic, tantalic, and niobic acids. It likewise fails to give the blood-red coloration in a bead with sesquioxide of iron, produced by these acids. The fluxed mass, if water and acetic acid are carefully added, and then evaporated on the lamp-plate, separates gelatinous hydrate of silica. Fine splinters of silicates give, upon fusing in the bead of microcosmic salt, a gelatinous skeleton of silica, floating in the fused or cooled bead.

XXX.—Behavior of Chromium Compounds.

A, *In the platinum spiral with carbonate of soda*, the compounds of chromium when fluxed with the repeated addition of nitrate of potash, give a bright yellow mass, which, when knocked off on to the lamp-plate, and crushed, gives a bright yellow solution. If this solution is separated from the residue, by carefully allowing it to run off, and acidified with acetic acid, it becomes yellowish-red, and gives with lead salts, when it is soaked up into strips of paper, a yellow precipitate, with solution of salts of oxide of mercury a red one, and with solution of silver salts a reddish-brown one.

With sulphide of ammonium, as well as by evaporating with aqua regia upon the lamp-plate, the solution becomes green; likewise with proto-chloride of tin.

B. *The borax bead* becomes emerald-green in the oxidizing flame, and does not change this color in the reducing flame.

XXXI.—Behavior of Vanadium Compounds.

A. Upon treatment of compounds of vanadium with carbonate of soda and nitrate of potash in a platinum spiral, a bright yellow fluxed mass is obtained, the solution of which, acidified with acetic acid, is precipitated yellow by nitrate of silver. The fluxed mass when heated with aqua regia does not give a green solution, but a yellow or yellowish-brown one, which only becomes blue after the addition of proto-chloride of tin. If the fluxed mass contains much vanadic acid, its solution, when much concentrated cold hydrochloric acid is added to it, gives a yellowish-brown color or precipitate.

B. *In the borax bead*, compounds of vanadium produce in the oxidizing flame a greenish-yellow color, in the reducing flame a green color.

XXXII.—Behavior of Manganese Compounds.

A. *Borax bead*, amethyst in the oxidizing flame, colorless in the reducing flame.

B. *With carbonate of soda on platinum wire*, a bead is formed green after cooling, especially easily after addition of nitrate of potash. Water extracts a green solution from it, which becomes red after the addition of acetic acid, and then, often with the separation of brown flakes, becomes colorless.

XXXIII.—Behavior of Uranium Compounds.

A. Give a yellow bead in the oxidizing flame, which becomes green in the reducing flame, especially easily after moistening with proto-chloride of tin. The colors are very like those of the compounds of iron: they can, however, easily be distinguished, if no other oxide which might impart a color is present, by the fact that the uranium bead emits a bluish-green light during ignition, similar to that which the uranium compounds manifest in fluoresence. Borax beads of oxides of lead, stannic acid, and several other substances manifest upon ignition a similar appearance, but are not of the same color after cooling as the uranium bead.

B. The insoluble compounds of uranium are fluxed by treatment with bisulphate of potassa, near red heat in the fine platinum spiral. The fluxed mass is triturated with a few grains of crystallized carbonate of soda, and the liquid portion of the triturated and somewhat moistened mass is soaked up into blotting paper. With

ferrocyanide of potassium a brown spot is produced upon the paper moistened with acetic acid.

XXXIV.—Behavior of Compounds containing Phosphorus.

These can easily be detected in the following manner, even if mixed with a large amount of other substances:—The test-specimen, after ignition, is crushed fine upon the lamp-plate, and placed in a glass tube, drawn out to the thickness of a straw, and fused shut at one end, and a piece of magnesium wire, two lines long, is added, which must be covered by the test-specimen. When the tube is heated phosphide of magnesium is formed, whilst the contents glow intensely. The black contents of the tube, after it has been crushed upon the lamp-plate, give when breathed upon, or moistened with water, the very characteristic odor of phosphuretted hydrogen. In the absence of magnesium wire, a small piece of sodium will answer as well.

B. If it has been ascertained that the test-specimen does not give an incrustation upon porcelain in the upper oxidizing flame, the phosphates can also be recognized by the fact, that they give a polished fused globule of phosphuret of iron upon platinum wire, with boracic acid, and a piece of iron wire, of the fineness of a hair, in the hottest lower reducing flame, which can be drawn out of the boracic bead, crushed under paper, by means of the magnetic knife-blade.

XXXV.—Behavior of Sulphur Compounds.

A. *On a charcoal rod with carbonate of soda*, in the lower reducing flame, they give a fused mass, which moistened upon a piece of silver blackens it. Since selenium and tellurium produce the same reaction, the absence of these substances must be determined by the absence of a tellurium or selenium spot upon porcelain.

B. Where only metallic sulphides are to be considered, and not sulphates, it will answer simply to heat the test-specimen in the flame in order to recognize sulphur by the odor.

(To be continued.)

EDUCATIONAL

THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

(Continued from page 278.)

THE MEGASCOPE.

IN any course of lectures on optics, the manner in which an image is formed by a lens, must, of course, be discussed, and it becomes very desirable that some demonstration should be given of the fact that not only do luminous objects, such as the flame of a candle, emit rays, which, when sorted, as it were, and focalized by the lens, produce images on a screen, but that other bodies, also, which are only illuminated by light, foreign to themselves, reflect it in such a manner as to bring them in this relation to lenses, in the same condition as self-luminous objects.

In addition to this, notwithstanding all the drawbacks (and we shall see that there are many,) which attend the adjustment of this experiment, yet within its proper limits, and with such judicious selection of objects as we shall presently describe, the projection of images from non-luminous objects is one of the most surprising and agreeable of experimental demonstrations.

It therefore becomes very desirable to adjust the lantern for use in this manner, and, after some experiment, I have succeeded in accomplishing this with very little change in the arrangement, or addition to the parts of the lantern already described.

We need, in fact, nothing additional to the lantern formerly noticed, Vol. 54, p. 132, but a simple lens mounted in a cell, and having a diameter of about four inches, and focal length of twelve inches.

In this case (referring to the cut, 10, on the page just cited,) we remove the condensers and objectives, and substitute for the latter, the lens above-mentioned, connecting it with the hole left by the condenser in the lantern, by a short tube sliding into the said hole, and with a cloth thrown around it, to stop up any cracks which may be left.

Within the lantern, we then turn the jet and lime entirely round, so that it throws its light towards the back door, and move it as far

to one side as possible. If a large prism of lime is used, no further precaution is needed; but if a small piece which becomes heated luminously on both sides, is employed, a little shield of tin, or the like, must be attached to prevent its light from passing directly to the lens. The inside of the back door is finally covered with a piece of white paper.

Matters being thus arranged, introduce one hand through the curtained opening in the side door, and with the other adjust the lens front and back for the focus.

An image of the hand, of gigantic size, will then appear on the screen, which, if other things are in good order—*i. e.*, the lime-light bright and the room dark—will, on the first trial, astonish the operator as much as any one else. The combination of color and motion, with strong effect of light and shade, will produce an appearance of relief or solid extension, compared with which the best displays of the dissolving lantern are insignificant. I can yet remember my own impressions on first trying this, and that with my own hand in the lantern, and giving to my own fingers the motions I saw repeated on the screen, it required an effort to realize that the image seen was something depicted on a flat surface, and not a huge solid body projecting into the room, and capable of seizing anything which approached.

This effect can be admirably produced in a room about forty feet square, on a good screen of twelve feet in diameter, and with the lantern about twenty-five feet from the screen. What is required for larger rooms, we will state presently.

Besides the hand, which is one of the most striking objects which can be employed, we have in order of merit, the works of a watch, so held as to reflect the light fully; a wine-glass full of wine, or wine-colored liquid; a strongly-marked miniature or photograph in an embossed metal frame; a small, metal coal-oil lamp with chimney, burning; a rosy-cheeked apple, &c.; plaster medallions with strong relief; a colored picture, which, however, shows poorly, because coming in contact with the more brilliant magic lantern display of the same objects.

An apparatus of some sort to display opaque objects, as above, has been repeatedly devised and exhibited, and has gone out of use again, chiefly because too much was claimed for it, and the disappointment of unreasonable expectations gave it discredit.

For reasons which were fully discussed in one of these papers

(see Vol. LIV., p. 340), it must, of necessity, even with the most costly lenses, be vastly inferior to the magic lantern in sharpness of definition and flatness of field, while in amount of illumination it is enormously behind.

If, then, we expect to substitute it in any way for the other instrument, we shall certainly be disappointed; but, if at a little cost, we can add it to the other, and use it only for those few experiments for which it is fit, and which cannot be in any other way produced, it will be found of much interest and service.

Sir David Brewster, in his "Natural Magic," p. 86, was, we believe, one of the first to suggest such an arrangement, which, however, as there indicated, is quite impracticable. In another paper on the magic lantern, he even proposed to arrange a solar or gas microscope, in like manner, for solid objects, which shows us how far one may go astray by allowing invention to run unchecked by fact or reflection. Dr. Pepper, in his very suggestive "Play Book of Science," p. 286, describes a plan which would be admirable, if one only had a first-rate parabolic mirror; and, on page 308, another, to which we presume the artist and engraver have not done justice, for certainly no such instrument as is represented would ever produce the results stated.

If the apparatus is constructed in any manner as described, it must be very costly and feeble in illumination.

Those who have arranged these instruments, have generally concerned themselves much with arrangements for concentrating light on the object by means of mirrors, &c.

This we believe to be quite unnecessary, for a lime-light brought as near to the object as possible, without burning it, will illuminate it fully as well as if the same light is set further off and has its rays concentrated by any optical means.

The objection to two lights is, that they destroy effect of relief, and are only of use with pictures, which are exactly the sort of objects least available for this instrument.

When I use this apparatus in a larger room than that described before (say one fifty by eighty feet), and where, therefore, more light is required, I employ a lens of six inches diameter and twenty-inch focus, with a double jet (the two jets within a half inch of each other,) and a larger lantern-box.

(Continued from page 283.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.

Above all, the error contemplated is to be removed by dispelling the mists that obscure the distinction between *collegiate* (scientific) and *professional* (scientific) or *polytechnic* education, as to their *range*, and *aims*, and *governing ideas*.

But this can probably never be accomplished by words alone. The truth must infiltrate itself into the popular mind by means of familiarity with practical examples of High Schools, Colleges and Professional Schools, each in due degree and proportion, and mutual adaptation, devoting itself principally to mathematical, physical and graphical science.

As the case now stands, the middle member of the three successive institutions just named, is practically found in the "scientific courses" parallel with the "classical" ones, in some colleges, also in the earlier stages of the polytechnic schools. But it has no separate formal existence yet; and, as the two substitutes for it, just described, partly cover the same ground, there is a lack of system and order yet to be supplied. Therefore, as before explained, since the existing polytechnic (professional) schools best know what preparatory courses of general or collegiate disciplinary cultures they require, let them create the collegiate order of institutions to which such courses belong, by a process of development and division out of their own substance.

We are now free to say, that the next great step by the professional schools of science, after the establishment of a four year's course of study, is the *extension* of that course by at least one year, with at least no depression of the conditions for admission: and then the division of that total course into two formally distinct and well-defined successive classes, viz:

A general disciplinary or collegiate course, composed of general science, and modern literature and philosophy, and

A technical, that is, a professional course in the theory and illustrated practice of each of the professions at least, whose basis is in the exact sciences, viz: Architecture and Engineering, the latter in

its well-defined branches of road and bridge engineering, hydraulic engineering, mechanical engineering, mining engineering. *Civil* Engineering proper, relating to works for the *general* benefit and use.

Having thus again reached and confirmed the same conclusion as before, we shall next endeavor to explain, in detail, the scope and composition of the two successive courses above defined.

In the *general* course, the *primary* and *immediate* object would be the development *of mental power*, or in the well-worn phrase, the "discipline of the mind."

In the technical courses, the immediate object would be training for the practice of any of those high industrious callings requiring an extensive and exact knowledge of principles, together with expertness in the elements of various departments of practice,—chemical, geodetical, graphical, &c.

But before going further, truth to the facts of life requires an important explanation. Observe that we say, "the *primary* and *immediate*" object of the general course is development of mental power in the student, irrespective of any practical pursuit to which he may apply that power. We speak thus, because of the cardinal truth that things *logically* separable are *vitally* united. In other words, things distinct or distinguishable in *thought*, are intimately united in *real life*.

To illustrate, by reference to physical culture. A young man going through a course of general gymnastics would be said to be *immediately* seeking a sound general muscular development—in symmetry, power and flexibility, with certainty of accurate concerted action between eye and limbs.

Nevertheless, if the youth contemplated a subsequent career as an expert skater, swimmer, oarsman or horseman, he could not but enter upon his general gymnastic practice, with more zeal and vigor if he regarded not only its *immediate* end as above described, but also its *ultimate* end as a foundation for the subsequent proposed branch of special skill.

Now the point is this. Earnest spirits cannot but be chiefly enlisted in the contemplation and pursuit of *ultimate* ends; of final and practical or "concrete" results.

Hence, though the *immediate* and *logical* end of merely general, commonly known as the collegiate grade of education, truly is the *conscious* development of actual mental working power in the student

out of his previously undeveloped capacities; yet who goes to college with this object steadily uppermost in his thoughts? Rather who does not go because *after graduating* (there is where his living thoughts, purposes and beckoning visions centre), he means to enter a professional course under the best conditions, in order to be a lawyer, physician, teacher, clergyman, or professionally a man of letters; and because he knows that he can better obtain these positions by bringing trained faculties to bear on the acquisition of them.

We have, then, these two principles:

I. Things separate or separable in thought, are vitally united in practical life.

II. *Ultimate* ends are both contemplated and pursued, with the steadiest and liveliest interest.

To which we add a third:

III. Classification of complex objects, as courses of study, is *not* based on the *exclusive* presence of some determining feature, but on its *predominance*. Thus, a classical education is not one which consists *only* of the study of the Greek and Latin languages and literature, but *principally* of these things.

So, then, to be true to mental life, we would say that both in *general* and in *professional* education, some future sphere of high activity is the *practical* end, cherished with most pleasure and with most *effect* upon daily progress. Only, fitness for such activity is the *immediate* end of *professional* education, and the *remote* end, only, of general *collegiate* or "disciplinary" education.

But mental discipline itself is likewise an end of both grades of education. Only it is the *primary* (*logical*) end of general or collegiate education, and the *incidental* (though truly a real) end of professional education.

To complete this branch of our discussion, we will re-define, with an effort at improvement, four marked successive grades of education mentioned in the "Notes of Pol. Schools" by the present writer. The whole of systematic education exists in two graded divisions:

I. Study *passively pursued*, that is, all which *precedes* the age of conscious self-culture and development; and consequent intelligent preference of one line of future study to another; and choice, or at least, interested deliberation upon future life-pursuits.

II. Study *actively pursued*, embracing all which succeeds the recognized attainment of the age just mentioned.

In the former case, the child acts from instincts of obedience to an external guiding power, viz., parental authority.

In the latter stage, the student, properly so-called, obeys an impelling law within himself, and is self-destinated; though the means for attaining his self-determined destination are, because of his inexperience, selected by those who have already entered upon their self-chosen career of practical life.

The relation of these grand divisions to each other, is this: the object of the former is, to develope the mind up to the point of choosing its subsequent line of study for itself, agreeably to its self-chosen future career. Further, each of them exists in two parts. The *first* embraces:

1. *Rudimentary education*, which is that without which there can be no knowledge, so far, of course we mean, as knowledge results from school instruction. Thus, without knowing how to count and add and subtract, there can be no knowledge of numbers, or reckoning, or of relations of quantity.

2. *Elementary education*, which extends to operations involving the use of one or more of the rudiments; as in arithmetic again, operations on vulgar fractions, square-root, least common multiple, &c., involve the single or combined use of "ground rules."

The *second* grand division embraces—as already stated—

1. *General education*, whose *immediate* and *logical* end is, development of mental power; but whose *remote* and *practical*, and withal *chiefly operative* end, is practical success in life.

2. *Professional education*, whose *immediate* end, both logical and practical, is actual fitness for a chosen practical sphere of action; and whose *incidental* and *real*—even if unthought of—end, is further mental discipline.

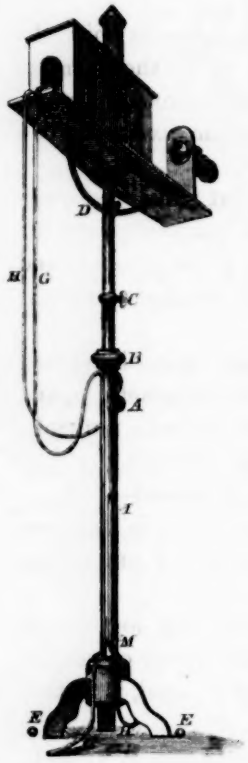
To finally complete this discussion, nothing now seems wanting but to broach a curriculum for each grand division of an institution, embracing its own collegiate training within the sphere of its own organization.

This, at a future time, we will attempt to do, coupled with comments on the unrecognized purely disciplinary power residing in certain branches of study.

R. P. I., March, 1868.

NEW STAND FOR A LANTERN.

In order to render possible a wider range of lecture experiments on the subject of Light, with the ordinary magic lantern, the following construction for a stand has been resorted to. The base of the stand is a small wooden tripod, with a heavy oaken central block. The spread of the limbs of the tripod is so small, only fifteen inches, that they are entirely out of the way, and at the same time, by means of thumb-screws, which are passed through iron plates, E E, the stand is made firm. Securely fixed into the tripod is an iron tube, an inch and a half in diameter, which rises to the height of forty inches from the floor, and is capped with a wooden annulus, B. An iron rod slides up and down in the tube, carrying with it the table tops, two in number, the smaller one fifteen inches by twenty-three, the larger, twenty by thirty-seven inches. The former is permanently fastened, the latter is attached, when needed, by screws. The sliding rod is prevented from leaving the tube by a ring at its lower end, which strikes against the annulus, B. It is fixed at any height by a screw with a ringhead, A. C is a brass ring with a clamping-screw, which can be secured anywheres along the sliding rod. When the screw A is loosened and C fixed, the table falls until C strikes upon B; it may then be revolved through any angle, and again secured by A. On the lower side of the smaller table-top are two wooden strips, provided with holes for the ends of a cross-bar, which is fastened to the top of the sliding rod, and upon which the table turns. It is fixed at the required elevation by the screw P, which passes through the sliding rod, and presses against a semi-circular iron hoop, with a radius of six inches. G and H are the tubes for conveying the Oxygen and Hydrogen gas. The part I attached to the stand, is copper, one-quarter of an inch in diameter. It is attached by a short connecting tube, one-sixteenth of an inch



diameter, with a tube three-quarters of an inch across, and two inches deep, closed at both ends, so as to serve for the reservoir of a water-guage, M. Another tube, of copper, soldered into this, and passing down to the bottom of the copper bottle, is connected, by a short india-rubber tube, with a glass tube, for indicating the pressures. Only one of the tubes and gauges is seen in the drawing, the other being upon the opposite side of the stand.

The lantern box is fastened to the table-top in such a way as to be disengaged in a very few moments. Four plates of iron are secured fast to the bottom of the lantern, and four more are let in flush with the table. Through the former, iron keys are passed, which fit into openings in the latter, and a quarter revolution of the keys fixes the lantern securely.

Demonstration of the Refraction of Light.—It has been customary, in the demonstration of the refraction of light to a large class of students, to place the lantern with the line or electric light, in a horizontal position, and alter the direction of the ray until it struck upon the surface of the refracting body at the desired angle. This change of direction was effected either by a square prism or a plain mirror. The foregoing arrangement of the table, permits the direct ray to be sent in any path with equal facility. The tank for performing the experiment is best constructed of two semi-circles of plate-glass of one foot radius, separated by an india-rubber strip, such as photographers use for their large baths, at an interval of one inch and a half, and clamped together in a brass cell. On the forward side of the latter, the graduation may be made. The cost of this elegant piece of apparatus is not great. A diaphragm placed in the lantern with three holes, a quarter of an inch in diameter, and placed in a vertical line, will allow three slightly divergent beams of light to pass through it—their change, of course, at the surface of the water in the tank, is very noticeable.

Examination of Precipitates.—The top of the table is turned into a vertical position, so that the nose of the lantern points to the zenith. A square prism fastened by side tabs to a brass or tin ring, which fits tightly into the draw-tube of the objective, turns the ray of light through a right angle, and causes it to fall upon a screen placed in the usual position. There is not that difficulty about the management of the light, which might at first thought be expected. The board which carries the cylinder, is prevented from falling out at the rear, by a little slip of brass fastened by a screw at one end,

and slipped around upon the board when necessary. Care, however, must be taken, that the lenses forming the condenser, be not too cold at the time of commencing the experiments. Otherwise, the moisture which is so abundantly formed by the union of the gases, will be precipitated in such quantities as to cause serious inconvenience. A sudden change of temperature, moreover, may fracture the lens. The vessel in which it is intended to perform the reactions, is placed upon the condenser of the lantern. The depth of liquid should not exceed one inch. Chemical changes thus seen in plan instead of elevation, so to speak, assume a very novel appearance. The fluid, before perfectly colorless, perhaps, is thrown into undulations by the sudden entrance of a drop of the reagent, and then from the latter as a centre, wreaths of the colored precipitate make their appearance. An ordinary glass vessel does not answer very well for these experiments. The bottom of such is always more or less lenticular, and while it may render the picture on the screen more curious-looking, it does not contribute to a proper understanding of the reaction. A dish which entirely obviates this difficulty, may easily be constructed in the following manner. A disc of plate-glass five and a half inches in diameter, or three-quarters of an inch more than the diameter of the condenser, is easily cemented into a ring of tin or brass, and forms the bottom of a shallow vessel. Although scarcely necessary, a coating of paraffine protects the metal.

Cohesion Figures.—While a vertical tank may serve for the exhibition of precipitates, it will not do at all for Cohesion Figures, which are formed only at the surface, and which to be seen properly, must be viewed from a position vertically above or below the liquid. The arrangement just described, puts a large audience in the position of a single observer. Seen upon a screen, and greatly magnified, these figures have a most peculiar appearance. They are formed when a drop of sulphuric ether, alcohol, naphtha, the oils of almond, clove, lavender, colza, sperm, olive, or of creosote, carbolic acid, &c., falls upon the surface of water. For a full account of them, see the *Philosophical Magazine*, October, 1861. The vessel should be chemically clean, and the water pure. The Cohesion Figure formed by ether or alcohol, is of too short duration to be satisfactory for a screen experiment—that of creosote and others, is better.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, March 18th, 1868.

THE meeting was called to order, with the Vice-President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting, held March 11th, inst., a letter was received from Lieut. Col. D. E. Macpherson, of Allery, Melrose, Scotland, announcing the death of his father, Sir David Brewster, on the 10th of February, ult., in the 87th year of his age, which was referred to the Institute to take suitable action.

Donations were received from the Royal Astronomical Society, the Statistical Society, the Society of Arts, the Royal Geographical Society, the Institution of Civil Engineers, London, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; l'Academie des Sciences, and la Société d'Encouragement pour l'Industrie Nationale, Paris, France; J. Smith Homans, Esq., New York; Hon. G. M. Dodge, Chief Engineer Union Pacific Railroad, Omaha, Nebraska; Dr. John F. Boynton, Syracuse, New York; Dr. J. Graham Tull, and Dr. Thomas S. Kirkbride, Philadelphia.

The various Standing Committees reported their minutes. A paper on Telescopic Measurements was read by Mr. B. S. Lyman, Mining Engineer.

The Secretary's report on Novelties, &c., was then read.

A committee consisting of Prof. R. E. Rogers, M.D., and Prof. H. Morton, was appointed by the President to prepare resolutions on the death of Sir David Brewster.

After which the meeting adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notices.

A Treatise on Meteorology. By Charles Loomis, LL.D., Professor of Natural Philosophy and Astronomy in Yale College. Harper & Brothers, New York. J. B. Lippincott & Co., Philadelphia.

The above work, gotten up in a plain, substantial style, is intended chiefly as a text-book for students. It is illustrated by a

large number of wook-cuts, and three steel engravings. It is printed in short, concise sentences or divisions, faced with bold type which at once catches the eye, and gives the work an interesting appearance. The first three chapters are devoted chiefly to the temperature and tension of the atmosphere, and the instruments for measuring it.

Chapter fourth is devoted to the motions of the atmosphere; the trade-winds; causes of the winds; hot winds of the desert, &c.

Chapter fifth is an exceedingly interesting one, upon the precipitation of vapor contained in the atmosphere. Under this head are included the formation of dew; formation of hoar frost, fogs, clouds, rain, snow and hail.

Chapter sixth relates to storms, tornadoes and water-spouts; the cause of storms, &c; cyclones; paths of cyclones and tornadoes; disastrous effects of tornadoes and whirlwinds, water-spouts and pillars of sand; showers of toads, fish, oranges, &c.

The next chapter is devoted to predictions of the weather, from various causes, as from the clouds, dew, hales, coronæ, &c.

Several chapters are next devoted to electrical phenomena, atmospherical electricity, electrified clouds; lightning in its various forms, as fork or zigzag, ball lightning, sheet lightning.

Causes of thunder; the aurora borealis; theory of the polar light; twilight; twinkling of the stars; shooting stars; meteors and aerolites.

After this is a series of most valuable tables—thirty-six in number—comprising the relative humidity of the atmosphere, the conversion of French into English measures, &c.

At the end of all is a list of works on meteorology, such as advanced students require. When we first opened this book, we were disposed to expect something exceedingly dry and void of interest to all but the professional meteorologist: masses of tables embodying observations and their elaborate discussion. Our intention was to glance over it, and report the result of this general inspection. In place of which, however, we have read it through with lively interest, and have derived much information from the perusal. It has quite revolutionized our ideas of the science called meteorology, and has revealed the fact that in place of the mere tabulated record which, in the mind of most, represents the subject, it includes some of the most interesting and beautiful phenomena in the range of natural science.

An Introduction to Chemical Philosophy according to the Modern Theories. By Dr. Adolphe C. Wurtz, F. R. S., translated from the French, by permission of the author, by Wm. Crooks, F. R. S. London: J. H. Dutton, "Chemical News" Office. 1867.

The present volume presents a concise and systematic view of the birth and growth of chemistry as an exact science. It begins with the history of the terms Equivalent, Atom and Molecule. The idea of equivalency originated in some crude experiments made by Homberg, in 1699, to determine the quantities of different acids which would be required to saturate the same weight of base. It was established on its present firm basis, so far as acids and bases are concerned, by the more accurate researches of Wenzel, in 1777. About the year 1804 Dalton discovered that for the same quantity of carbon, the quantity of hydrogen in marsh gas is twice that in olefiant gas, and that an analogous multiplication exists in the compounds of oxygen with carbon and with nitrogen. To explain the law of multiple proportions thus discovered, he promulgated his doctrine of atoms, and made them serviceable in the conduct of analysis, by assigning to them proportional weights: the weight of the hydrogen atom being taken as unity.

But the great discovery which linked chemistry to physics, and which is rapidly creating, I apprehend, a chemico-mathematical science, was that of the combination of gases by volumes, published by Gay Lussac, in 1808. It derives additional importance from the remarkable behavior of bodies in their gaseous condition, in that they suffer an equal amount of dilation and contraction for the same change of temperature and pressure. Hence Ampére inferred that equal volumes of two gases contain the same number of atoms, and that the weights of the atoms of simple gases are proportional to their densities. For example, one measure of oxygen gas containing the same number of atoms as one measure of hydrogen, while it is sixteen times greater in weight, the weight of the oxygen atom must be sixteen times greater than that of the hydrogen atom. The value of these atomic weights was immensely increased by the discovery, in 1819, by Dulong and Petit, that these numbers represented the weights of the elements, with some exceptions, which had the same capacity for heat. This being the case, the specific heat of a body becomes a vital consideration in the determination of its atomic weight. In the following year,

modern chemistry, as the science which has for its great prerogative the investigation of the nature and changes of position among *atoms*, received another vast addition in the discovery by Mitscherlich, of Isomorphism.

A great confusion now arose in the minds of chemists, and still, unhappily, prevails in many, with regard to the true signification of the terms Equivalent and Atom. It springs from the fact that the quantities of different elements which enter into combination with the same quantity of a certain element, and which are properly called equivalents, are not always the same as the atomic weights. Thus a quantity of oxygen represented by 16 enters into combination with a quantity of hydrogen represented by 2, while to saturate the same weight of hydrogen, 71 parts of chlorine are required. Hence, 71 parts of chlorine are equivalent in respect to 2 parts of hydrogen to 16 parts of oxygen; but while the atomic weight of oxygen is to be taken at that of 16, that of chlorine is but 35·5. The same is true with regard to acids and bases. After perplexing the minds of chemists for many years, the confusion is now being done away by the assignment of different equivalential atomic values. As a further consequence of this last-named distinction, the fundamental difference between atoms, in respect to their substitution value, or *atomicity*, as it has been happily called, towers into prominence.

It would be interesting to trace with the author the expansion of the foregoing ideas, and the rich fruit of high knowledge in chemistry which their full apprehension is bearing. But the foregoing will induce the chemist who desires to see the beautiful lands of promise which are now being opened out to view, rather than to dwell among the withered ideas of the past half century, to give this completest treatise on the subject of modern chemical philosophy, which has as yet appeared in English, a delighted perusal. The language is terse, the reasoning, though clear, profound. The book is a model worthy of imitation: the work of a master mind which has predicted discoveries by the *a priorie* light of logical analysis, and which has afforded to many recent theories a solid foundation of well-conceived and accurately executed experimental researches.

Engineering Facts and Figures for 1867. An annual register of progress in mechanical engineering and construction, with notes on the various departments of the Paris Exhibition, 1867. A. T. Fullerton. London. J. Pennington & Son, 127 South Seventh Street. Price $3·00.—Free by mail.

The title of this book gives some notion of its character, and beside the previous volumes for former years are well known and widely circulated. We may, however, remark that this volume, like its predecessors, is chiefly a condensed abstract of the more important papers on the subjects specified which have appeared during the year in the best scientific periodicals.

In the present case, we have excellent papers on the following classes of subjects, each class including more individual discussions than we could possibly here enumerate: 1. Boilers, &c.; 2. Fuel and Furnaces; 3. Steam Engines; 4. Other Prime Movers; 5. Tools; 6. Mechanical Appliances; 7. Metals; 8. Railways; 9. Marine Engineering; 10. Agricultural Machinery.

Within the very brief limits to which such a notice as the present must be confined, it is quite impossible to discuss the merits of such a book as the above, which is actually the work of an hundred authors of very various degrees of ability and information; but we can say, most emphatically, that no mechanical engineer will fail to find in it a vast amount of information of the greatest value to him in the prosecution of his business.

Among the articles which have chiefly engaged our attention, we would mention, firstly, that on boilers, including notices of the Howard, Field, Harrison, Martin, and many other special plans; a general discussion of Marine boilers, of the principles of boiler construction, and setting of vessels for generating steam at large. Secondly, that on boiler explosions, which includes some articles published in this *Journal* during the last year, and the section on Steam Engines.

We notice that the report of the Franklin Institute on the Harrison Boiler, is given in full, but as quoted in *Engineering*, without reference to this *Journal*, in which it first appeared.

On page 102, the author states that the Injector will not draw water from a greater depth than six feet, being evidently unaware of the improvement of Mr. William Sellers, by which it is enabled to raise water from a depth of sixteen feet. This improvement was exhibited in the late Paris "exposition."